

OCTOBER 1946

NO. 142



# Bulletin

New Specifications • Publication Prices • 1946 Book of  
Standards • Testing Resistance of Paints on Steel •  
Alkalies in Portland Cement and Durability • Dielectric  
Strength of Varnished Cambric • Soils • Elastic Proving Bar

American Society for Testing Materials

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# ASTM BULLETIN

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# ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

R. E. Hess, Editor  
R. J. Painter, Associate Editor

CABLE ADDRESS—TESTING

Number 142

October 1946

## Society Accepts New and Revised Materials Specifications

ON THE recommendation of several of the technical committees the Society, through its Administrative Committee on Standards, on September 9 approved numerous new and revised specifications and tests. The accompanying table itemizes the various actions. It will be noted there are new tentative specifications or tests covering Magnesium-Base Alloy Extruded Round Tubing (B 217); Facing Brick (Solid Masonry Unit Made from Clay or Shale) (C 211); Calorific Value of Gaseous Fuels by the Water Flow Calorimeter (D 900); Test for Water-Vapor Permeability of Packages (D 895); Resistance of Adhesive Bonds to Chemical Reagents (D 896); and Tensile Properties of Adhesives (D 897).

### *Magnesium Extruded Tubing:*

This new specification covering a product in rather widespread commercial use virtually gives the Society complete coverage through its numerous specifications and tests of the various commercial wrought magnesium alloys and products. In B 217, four types of alloys are provided, three carrying aluminum ranging from 2.5 to 9.2 per cent, respectively, and the fourth being a manganese composition with a minimum of 1.20 manganese. The tensile requirements for the alloys carrying aluminum range from 34,000 to 38,000 psi. while the other alloy has a minimum of 28,000 psi.

### *Compressive Strength of Mortars:*

The revisions here concern the determination of flow and the molding of the test specimens. In general they effect a saving in the operator's time and in the amount of

standard sand required. These revisions will be published for a year or more before adoption.

### *Masonry Building Units:*

Committee C-15 on Manufactured Masonry Units, in addition to the new specification for facing brick, had developed numerous revisions in its other specifications and tests. The new tentative C 212 meets the need for requirements for facing brick since the recent trend has been to differentiate clearly between common and facing brick. Two grades are covered, for use where there is frost action and disintegration by weathering or where there is no such deteriorating influence. The requirements cover compressive strength which for the two grades must not be less than 2500 and 3000 psi., respectively (average of 5 brick); and there are requirements on extent of chippage, appearance, size and warpage, etc. The revisions in other standard specifications are set up for various reasons: in the Building Brick Specification (C 62), to make it conform to modular planning; in the Structural Clay Non-Load Tile (C 56), marking requirements are established; these also apply in the case of C 57.

The new Tentative Definitions of Terms (C 43) involves numerous changes and additions. The older definitions were obsolete in some respects and new terms had come into usage. The definitions cover various raw materials, tile, surface features, and such matters.

### *Paint and Related Materials:*

The change in Method of Preparing Steel Panels (D 609) is in-

tended to improve the surface of the panel and therefore the whole testing procedure. The changes in other tests in general bring the methods up to date and in the case of the Specifications for Zinc Chromate (D 478), requirements for additional pigments have been incorporated.

### *Calorific Value of Gaseous Fuels:*

This new method is the first of a series of testing procedures which will result from research work extending over several years, carried out under the auspices of Committee D-3 on Gaseous Fuels. The committee has sponsored a great deal of cooperative research at the National Bureau of Standards and in numerous other laboratories involving methods for determining specific gravity and density, water vapor content, the complete analysis or chemical composition of fuels, the collection of samples, and calorific value. Some of this work has involved the design of new equipment, and a large number of samples of fuels have been distributed for round-robin tests in the cooperating members' laboratories to evaluate the proposed procedures which were developed.

The new methods for calorific value (D 900) comprise a very extensive document covering definition of the terms, the standardization of which in itself was an important achievement, testing procedures which involve adjustments for humidity correction and control, and finally the calculation of the calorific value. This section gives discussion of the theory of the method of calculation as well as procedures for arriving at the *total* and *net* calorific values.

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### Water-Vapor Permeability of Shipping Containers:

After considering various proposed methods and after reviewing the results reported by various members of the group concerned, Committee D-10 on Shipping Containers recommended the new tentative test D 895. This applies to finished containers when they are closed and sealed in the conventional manner. Water-vapor permeability for this particular test is defined as the rate that water is transmitted into the container from the test atmosphere of  $90 \pm 2$  per cent relative humidity and  $100 \pm 3$  F. surrounding it while a desiccant is sealed within.

### Rubber and Rubber Products:

The change in the Tentative Requirements for Rubber Sheath Compound (D 532) eliminates vulcanizing in a metal mold, which test is considered superfluous, providing the physical requirements properties are met. The ozone-resistant type wire insulation (D 574) will have the value of the constant K in the formula for insulation resistance changed from 5280 to 2000. During the war, this constant was dropped to 1000 in the emergency alternate provisions. In effect, therefore, this change increases the constant to 2000. This value is the same as now used in D 754 and D 755 covering synthetic rubber insulations.

Revisions in the Heat-Resisting Synthetic Rubber Compound Specification (D 754) will permit the use of some natural rubber when this becomes available and will include additional types of conductors with the  $\frac{1}{32}$ -in. wall. In another specification for insulated wire and cable, performance synthetic compound (D 755), the use of natural rubber, and additional types of conductors are included, and, further, the aging requirements are made more rigorous, which is an improvement and which the manufacturers can meet.

The Methods of Testing Rubber Insulated Wire and Cable (D 470) are to include the horizontal flame test which had appeared during the war as an emergency revision. The change in the Test for Rubber Hose (D 380) will permit the use of a certified test slab from the same material as used in the hose in cases

## Actions by the A.S.T.M. Administrative Committee on Standards, September 9, 1946

### New Tentatives

#### Specifications for:

- Magnesium-Base Alloy Extruded Round Tubing (B 217 - 46 T)
- Facing Brick (Solid Masonry Unit Made from Clay or Shale) (C 211 - 46 T)

#### Method of:

- Test for Water-Vapor Permeability of Packages (D 895 - 46 T)
- Test for Resistance of Adhesive Bonds to Chemical Reagents (D 896 - 46 T)
- Test for Tensile Properties of Adhesives (D 897 - 46 T)
- Test for Calorific Value of Gaseous Fuels by the Water Flow Calorimeter (D 900 - 46 T)

### Tentative Revisions of Standards

#### Specifications for:

- Structural Clay Load-Bearing Wall Tile (C 34 - 41)
- Structural Clay Non-Load Bearing Tile (C 56 - 41)
- Structural Clay Floor Tile (C 57 - 39)
- Building Brick Made from Clay or Shale (C 62 - 44)
- C. P. Zinc Yellow (Zinc Chromate) (D 478 - 41)

#### Method of:

- Sampling and Testing Brick (C 67 - 44)
- Test for Compressive Strength of Hydraulic Cement Mortars (C 109 - 44)
- Sampling and Testing Structural Clay Tile (C 112 - 36)

### Revision of Standard and Reversion to Tentative

#### Definition of:

- Terms Relating to Structural Clay Tile (C 43 - 46 T)

### Revision of Tentatives

#### Specifications for:

- Insulated Wire and Cable: Class AO, 30

- per cent Hevea Rubber Compound (D 27 - 46 T). (Two separate revisions)
- Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 532 - 46 T)
- Insulated Wire and Cable: Ozone-Resistant Type Insulation (D 574 - 46 T)
- Insulated Wire and Cable: Heat-Resisting Synthetic Rubber Compound (D 754 - 46 T)
- Insulated Wire and Cable: Performance Synthetic Rubber Compound (D 755 - 46 T)
- Cellulose Acetate Molding Compounds (D 706 - 46 T)
- Laminated Thermosetting Materials (D 709 - 46 T)
- Cellulose Acetate Plastic Sheets (D 786 - 46 T)
- Ethyl Cellulose Molding Powders (D 787 - 46 T)

#### Method of:

- Preparation of Steel Panels for Testing Paint, Varnish, Lacquer and Related Products (D 609 - 46 T)
- Test for Evaluating Degree of Settling of Traffic Paint (D 869 - 46 T)
- Testing Rubber Hose (D 380 - 46 T)
- Testing Rubber Insulated Wire and Cable (D 470 - 46 T)
- Testing Rubber-Coated Fabrics (D 751 - 46 T)
- Identification and Quantitative Analysis of Synthetic Elastomers (D 833 - 46 T)

#### Recommended Practice for:

- Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products (D 822 - 46 T)

### Revision of Emergency Standard

#### Method of:

- Test for Changes in Protective Properties of Organic Coatings on Steel Surfaces When Subjected to Immersion (E8 35), and Its Advancement to Tentative (D 870 - 46 T)

where the material is so thin that the minimum requirement of  $\frac{1}{32}$  in. cannot be made available.

A new alternate method which is particularly applicable to fabrics having low resistance to passage of moisture has been incorporated in the various tests for rubber-coated fabrics as established in D 751. This involves the Suter equipment. The adhesion test procedure is being modified so that the results should give a better average figure instead of the maximum values.

Of particular interest in identifying and analyzing synthetics is the incorporation in D 833 of spot tests, representing utilization of the results of recent work. These tests are more rapid and considered fully as reliable as those replaced.

### Testing Adhesives:

The new methods of testing adhesives—the first, Tensile Properties

of Adhesives (D 897); the other, Resistance of Adhesive Bonds to Chemical Reagents (D 896)—are the first that have resulted from the relatively new Committee D-14 on Adhesives. There is intensive demand for test methods for evaluating different types of adhesives and possibly also for performance type specification but the Committee has for the past year or two been concentrating its work on test methods.

The tension test will determine comparative properties of adhesives, using a standard shape specimen with specific conditions of pretreatment, temperature, and testing speed. The requirements give specific dimensions on the test specimens and their quality whether wood or metal, the gluing and conditioning, the number of specimens (at least 10 must be tested), and the general procedure.

The new test for resistance of ad-



hesive bonds to chemical reagents requires the use of the other new test for tensile properties, D 897. The testing procedure requires that each specimen shall be in a separate container, totally immersed in the reagent for 7 days at a temperature between 25 and 30 C., and the re-

agent is to be stirred every 24 hours. After rinsing with distilled water and drying, the specimen is tested immediately. Various standard chemicals are listed, including sulfuric acid of various strengths, sodium hydroxide solutions, various alcohols and others.

Copies of all of the new and revised A.S.T.M. specifications will be available during the fall from A.S.-T.M. Headquarters, at 25¢ each and they are also being included in the new 1946 Book of A.S.T.M. Standards to be issued in December-February, in five parts.

## Announcement on Publication Prices

### Costs and Greater Size Compel Increases

WITH the great increase in the size of some of the A.S.T.M. publications, particularly the special compilations of standards many of which are issued annually, and in part due to greatly increased printing costs, the Finance Committee and the Board of Directors have authorized increased prices for most of the Society's publications which involve standards compilations. Although detailed information on the various publications will be sent to all members later in the Fall, and there will be included the special Members' Order Blank, it is desirable to give some advance information. A few of the books will be off press shortly and thus be available before the members get the special order blank.

Obviously, as the technical committees which sponsor the annual publication of specifications and tests in one compact volume, continue to develop new methods

and also to arrange for the inclusion of other technical material, the books increase steadily in size. Some of the compilations which a few years ago contained 200 to 300 pages now comprise 500 to 600. On top of this increased amount of material there have come higher composition and printing costs. As a result of these situations, and based on a rather comprehensive study of the whole A.S.T.M. publication schedule, the Finance Committee has authorized increased publication prices as noted in the table below.

None of the books listed is furnished to the members on their membership, but all of the standards included are available through the big Book of Standards. The Finance Committee is continuing the reduction, which enables members to procure these books at a considerable saving and the reduced prices to members apply on orders

in quantity as well as on single copies.

### Compilations Available Shortly

The Headquarters Staff is devoting intensive efforts, and the printer is also concentrating his work on getting out as many of the compilations as possible this Fall. Those on which presswork is under way include the new group of standards on electrodeposited coatings, the specifications and tests for cement, and the extensive compilation involving textile materials which book includes a considerable amount of technical information that does not fall into the category of a standard. Probably the next compilation to be issued after these will be the one on paper and paper products; then the schedule calls for the compilation of the oldest and probably most extensively distributed one, the compilation of standards on petroleum and petroleum products. It is hoped to have all of these publications in course of distribution before November 15.

#### Special Compilations with Related Material

| 1. Prices Increased to \$4.00:  |                                     |                                  |
|---|-------------------------------------|----------------------------------|
| Committee Sponsoring Publication  | Subject                             | Publication Date*                |
| B-5   | Copper and Copper Alloys            | April, 1946                      |
| D-1   | Paint, Varnish and Related Products | February, 1946                   |
| D-2   | Petroleum Products and Lubricants   | November, 1946                   |
| D-9   | Electrical Insulating Materials     | October, 1945 (February, 1947)   |
| D-13  | Textile Materials                   | October, 1946                    |
| D-20  | Plastics                            | May, 1945 (March, 1947)          |
| 2. Prices Increased to \$2.00:  |                                     |                                  |
| C-1   | Cement                              | October, 1946                    |
| C-8   | Refractories                        | April, 1947                      |
| C-9   | Concrete and Concrete Aggregates    | February, 1947                   |
| C-9-D-4   | General Aggregates                  | September, 1944 (March, 1947)    |
| D-5   | Coal and Coke                       | September, 1944 (February, 1947) |
| D-6   | Paper and Paper Products            | December, 1944 (October, 1946)   |
| D-12  | Soaps and Other Detergents          | September, 1945 (March, 1947)    |
| 3. New Publications (Prices Just Established \$1.25):   |                                     |                                  |
| B-8   | Electrodeposited Metallic Coatings  | November, 1946                   |
| C-14  | Glass                               | November, 1946                   |
| 4. A-1: The compilation of Standards on Steel Piping and Tubing as newly issued in November will be \$3.00. |                                     |                                  |

\* The data in parentheses indicates approximate date when new and revised publication will be issued. New prices are effective for both the current and new issues.

### 1946 Book of Standards:

A separate article on the next page of this BULLETIN gives advance information on the mechanics of issuing the 1946 Book of Standards which is to come out in five books—Part I on Metals and Part III on Nonmetallic Materials—General—formerly each in one book now are to be split into two books. In addition to the accompanying article on the Book of Standards, members will receive by direct mail further details.

## Methods of Furnishing 1946 Book of Standards

SPLITTING Parts I and III of the 1946 Book of Standards each into two separate books, which decision was announced in the August BULLETIN, entailed a complete study of how the Book which thus will be in five volumes would be furnished to the members. It also entailed a review of the list price as well as the price to members for extra copies. These matters were considered by the Board of Directors at its meeting on October 8 and based on the recommendations from the Publications Committee and the Finance Committee, the following scales were approved:

|  | SALES<br>PRICE<br>TO NON-<br>MEM-<br>BERS | SALES<br>PRICE TO<br>MEM-<br>BERS<br>FOR<br>EXTRA<br>COPIES |
|--|---|---|
| Part IA—Ferrous Metals   | \$ 8.00                                   | \$6.00  |
| Part IB—Non-Ferrous Metals   | 8.00                                      | 6.00  |
| Part II—Nonmetallic Materials—Constructional   | 12.00                                     | 9.00  |
| Part IIIA—Non-metallic—General (Coal, petroleum, soaps, textiles, water)             | 8.00                                      | 6.00  |
| Part IIIB—Non-metallic—General (Plastics, rubber, paper, electrical insulating)      | 8.00                                      | 6.00  |
| Annual Charge to Members (on their dues bill) for Book of Standards and Supplements: |   |   |
| Any one Part   | no charge                                 |   |
| Any two Parts  | \$4.00                                    |   |
| Any three Parts  | 6.00                                      |   |
| Any four Parts   | 8.00                                      |   |
| All five Parts   | 10.00                                     |   |

The distribution of the new Book in five Parts is admittedly somewhat complicated, but if the members will keep in mind two basic points it is believed there will be a minimum of confusion.

The points:

*The new 1946 Book will be distributed to members on the basis of their instructions which have been in effect for the past years. A member who got 1944 Part I, Metals, will get the two new Parts, IA and IB; a member who received all three 1944 Parts will get the complete 1946 Book in five Parts, and if he chose Part III in 1944, he will get the two new Parts, IIIA and IIIB.*

*The second point to keep in mind is that complete details of the new setup are being distributed to members in a separate mailing with a return card which will enable those who wish some change to be made in connection with future distribution of the Book and the 1947 and 1948 Supplements, to advise A.S.T.M. Headquarters promptly.*

Concerning the 1946 Book of A.S.T.M. Methods of Chemical Analysis of Metals which members could request during the year without charge, this will be furnished in the future at the special price of \$3 per copy.

The Board of Directors considered all of the angles involved in the new publication setup and felt that the new scale of annual charges which members will pay with their dues for extra parts of the book was fair, considering the extensive character of the books, and that the new sales prices will permit members to continue to purchase extra copies of the books at a considerable saving.

*The one point we would urge at this stage is for every member just as soon as he receives the direct mail communication and studies the descriptive*

*material, to decide what parts he wants in the future, and get the return form back to Headquarters at his earliest convenience.*

### "Heat Treating"

First prize-winning photograph, professional, in the Fifth A.S.T.M. Photographic Exhibit, by Robert A. Buchanan, U.S. Steel Corp. Research Laboratory.





# Round Table Discussion on Problems Encountered in Testing for the Humidity and Immersion Resistance of Paints on Steel

## INTRODUCTION

At the Annual Meeting, Subcommittee VII on Accelerated Tests for Protective Coatings of Committee D-1 on Paint, Varnish, Lacquer, and Related Products sponsored a discussion on "Problems Encountered in Testing for the Humidity and Immersion Resistance of Paints on Steel." The discussion was introduced by a paper by A. C. Elm in which he presents ideas and suggestions on the problems involved, some of which ideas resulted from an investigation conducted by the Research Division of The New Jersey Zinc Company (of Pa.) for the Bureau of Ships, who have granted permission to use the material. Mr. Elm's paper together with several prepared and impromptu discussions that were presented at the meeting are published herewith. These discussions generally pertain to topics suggested by the paper, such as reproducibility of tide range exposures; effects of nonuniform surface preparation; surface conditions wanted on steel panels; surface cleaning procedures; and means for determining whether a steel test surface is in proper condition to receive the test paint.

H. A. NELSON, *Chairman*  
Subcommittee VII

## Principles of Immersion and Humidity Testing of Metal Protective Paints

By A. C. Elm<sup>1</sup>

PERHAPS the most difficult task confronting the paint test engineer is the determination of the "durability" of an organic protective coating, that is, the protection it affords under conditions of actual service. The majority of painted articles are subjected to a wide variety of external influences which may vary over a relatively wide range so that it becomes very difficult to study the effect produced by each individual factor or by any combination or sequence of factors and to correlate the results into a reliable picture of the value of the paint as a protective medium. One solution of this problem consists of actual service tests on an extended scale and the application of statistical methods to the exposure results. In this case, no particular effort need be made at controlling or studying the effect produced by all variables individually, but a sufficiently large number of tests must be conducted so that the final average values arrived at will have

taken into consideration all kinds, degrees, and combinations of variable conditions. Despite its many advantages, actual service testing, however, cannot always be employed for several reasons, the most important of which is lack of time and suitable test surfaces. Therefore the paint test engineer is forced to resort to less time-consuming laboratory methods and for this reason he is greatly interested in establishing the reproducibility and validity of laboratory tests.

There are no proved or even generally accepted laboratory test procedures which would make it possible to state unequivocally that a given paint will or will not serve the purpose for which it is intended, and it is frequently necessary to design special testing equipment and procedures. This, however, appears to be a much more difficult and time-consuming undertaking than it should be, largely because the basic principles of laboratory testing are not fully appreciated. An analysis of some of these principles, therefore, may prove to be helpful and timely.

A discussion of the application of these principles to paint testing in

general would lead too far and would consume much more time than can be allotted to this paper. Therefore, this discussion will be aimed particularly at an analysis of the testing of metal protective paints by exposure to high humidity or immersion in suitable aqueous solutions, although much of what is said may be applicable to paint testing in general.

### DESIGNING A TEST

In designing a test procedure or equipment there are three distinct steps; namely, (1) the formulation of a theory of what is needed, (2) the actual development of an instrument or technique or both, and (3) the extensive use of this instrument or procedure to demonstrate its parallelity with actual service experience. The first of these steps is not only the first chronologically but also the first in importance. It is a waste of time and effort to design testing equipment or procedures before the problem has been fully defined and its aims clearly fixed. The necessity of diagnosing the problem correctly and working it out in considerable detail before entering upon steps (2) and (3) cannot be overemphasized.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

<sup>1</sup> Research Division, Technical Department, The New Jersey Zinc Company (of Pa.), Palmerston, Pa.

The purpose of humidity and immersion testing of metal protective paints is to compare various paint systems for their ability to protect metals against corrosion and destruction under service conditions where water or aqueous solutions are the principal deteriorating agents. For tests of this sort, paint films must be tested, firmly attached to a suitable substratum, and their relative abilities to perform their functions measured by the changes taking place in the substratum as a direct result of the exposure to the test conditions. To avoid misleading results it is essential that any significant changes in the appearance of the test specimen observed in the course of the test be the direct result and a quantitative measure of the failure of the coating to protect the substrate adequately and not the accidental result of any differences in the substrate, or unknown or uncontrolled variations in the environmental conditions. For example, when paint systems are to be compared for their ability to protect steel against rusting, care must be taken that any differences in rusting observed are a measure of differences in the protective coatings under test and are not due to differences in the corrosivity of the substrates or to some other external factor.

#### CONTROL OF SUBSTRATE UNIFORMITY

The substrate materials commonly available for paint tests of this sort are not uniform. Not only do members of a given panel series differ, but significant areas on the same panel may differ sufficiently to cause marked differences in the behavior of paint films. Therefore, to insure the reliability of panel tests for the quality of metal protective paints, the substrate specimens must be so selected and prepared as to guarantee (1) that each panel of a given test series is uniform in itself, and (2) that all members of the series, immediately prior to the application of the test paints, are as nearly as possible identical in behavior and properties.

In order to determine how this might be accomplished, let us look more closely at what is to be accomplished. It is desired to find a procedure which will permit the determination of the relative ability of a

given series of paints to prevent the corrosion of steel objects exposed to high humidity or immersed in water or aqueous solutions. The surfaces on which these paints are to be tested, therefore, should, in the absence of any protection, that is, when exposed in the unpainted condition, corrode at a uniform rate and to the same degree. Each individual member of the series should corrode uniformly all over its surface and should be as free as possible from pitting and other localized corrosion effects, and all members of the series should be alike in these respects. Any preparative treatment given the test panels should be for the sole purpose of making sure that this condition prevails.

It has been proposed that, in order to determine whether steel panels have been properly prepared, they be tested for their ability to support a film of water without break. Actually such a test serves only to indicate whether the panel surface is wetted uniformly by water. It does in no way guarantee that the same surface will also be just as uniformly wetted by the paint to be applied to it, much less would it indicate that the panels are identical in their response to failures of the test paints. What is needed is not necessarily a fat-free, rust-free, smooth or polished test surface but one that will promptly, reliably, and reproducibly indicate by visible rusting whenever a paint film fails to protect it against corrosive influences.

A test which may be useful in this connection was proposed by Mears.<sup>2</sup> A panel specimen to be tested for uniformity and corrosivity is dotted with a large number of droplets of a suitable corrosive liquid and the time of the first appearance of corrosion in each droplet as well as the nature of the corrosion product are noted. The average time elapsed to the first appearance of rust serves as a measure of the corrosivity while the nature of the corrosion product and the spread between these values for the various droplets measures uniformity. Hydrogen peroxide is a suitable testing liquid. It is unfortunate that this test spoils the panel for use in any paint test with-

out further treatment. Although we have not yet been able to do enough work with this test to establish definitely its reliability, we are confident that it will be of considerable help in the development of a procedure for pretreating paint test panels and as a routine control test for panel preparation.

For obvious reasons it is desirable to obtain results of practical significance in the shortest possible time. Therefore, it is not desirable to have the steel surfaces under the test films in a passive or only slightly active condition; on the contrary, it is preferable to have them in a condition of high activity or corrosivity, so that they respond readily to any failure of the test paint system to exclude corrosive agents. On the other hand, it does not seem desirable to aim at the highest possible degree of activity since in all practical cases some time must elapse between surface preparation and the application of the first coat of paint, and corrosion of the test surface during this interval should be avoided. Therefore it would seem preferable to aim at some intermediate degree of corrosivity which possesses sufficient stability to allow application of the test paint.

#### EFFECT OF PANEL SIZE

When paints are subjected to laboratory performance tests, it is usually necessary to reduce the size of the test area to a very small fraction of the area encountered under actual service conditions. This means that corners and edges occupy a relatively large portion of the test area. Therefore, corner and edge effects will be out of proportion to those usually encountered in actual service unless special precautions are taken to prevent an excessive influence of corners and edges upon the test results. Such effects are absent or greatly minimized on spherical or cylindrical test specimens of sufficient diameter. The mechanical difficulties encountered in preparing and handling such specimens, however, make them unsuitable for routine testing of metal protective paints. A practice of minimizing edge and corner effects which has been widely used consists of protecting all corners and edges with additional coats of paint or several coats of wax. This practice

<sup>2</sup> R. B. Mears and U. R. Evans, "The Probability of Corrosion," *Transactions, Faraday Soc.*, Vol. 31, Part 1, pp. 527-542 (1935).



has much to commend it and may be expected to give satisfactory results provided the original panel area is not so small that the paint or wax edgings reduce it to a size inadequate for the purpose in mind.

There seems to be little doubt that for the sake of uniformity of any one panel of a set it is necessary to avoid coarse contours and large grain size. This takes on added importance as the panel size is reduced. It seems futile to specify in detail the degree of smoothness needed, for it depends much on the consistency characteristics of the test paint and its ability to fill cracks and crevices, but it is readily appreciated that it should be of such a degree as to guarantee a continuous coating of adequate thickness when the test paint is applied according to the procedure specified.

#### EFFECT OF FILM IMPERFECTIONS

The objection may be voiced that test panels prepared with such care bear no relation to actual service experience and therefore are of little, if any, practical value. It has often been stated that there is hardly any paint job absolutely free from defects and scratches and that therefore the results obtained with imperfect panels were of much greater practical significance than any results obtained with perfect panels. In fact many paint test engineers favor deliberately scratching through the paint film to determine the resistance of the test paint to loss of adhesion and rust creepage from a bare area. There is no objection to such practices provided the results obtained with them are viewed from the proper perspective. Such a test does furnish valuable indications regarding the protection afforded by a paint system under a highly specific set of conditions. It must be remembered, however, that the results of such a test are significant only if the substrate areas bared in this way on the various specimens of a test series possess identical activity. This presupposes that the panels were originally of the same activity and that the scratch actually penetrates to and lays bare an area of active metal. In addition care should be taken that the ratio of damaged to undamaged area is not too far out of proportion

to that usually encountered in actual practice, or, if this cannot be avoided, that this factor is at least taken into consideration when the results are interpreted in terms of service expectancy. When an actual paint job, such as on a ship, is examined and rated, the effect of film damage automatically appears in its proper perspective, whereas on a panel deliberately scratched it is frequently so greatly out of proportion that it may completely upset the balance of the test results.

As far as the application of the test paint is concerned, it does not really make much difference what method is chosen as long as care is taken that the coating is continuous and of uniform thickness. Kittelberger<sup>3</sup> has shown that in immersion testing pin holes and exposed freely corroding areas of metal in electrical contact with the test specimen may exert a marked influence upon the type and rate of failure suffered by the test paint. It is obvious then that the effective film thickness is the thickness of the coating at the thinnest point. Therefore, methods of determining the film thickness of a coating by calculation from its weight and specific gravity may be very misleading. They make no allowance for either the uniformity of the coating or the roughness of the substrate surface. Continuity measurements such as those proposed by Young and Gerhardt<sup>4</sup> are very useful in determining the minimum coating thickness needed to produce a continuous coating on a given surface and therefore serve as a measure of the roughness of the substrate.

#### SELECTING A TESTING TECHNIQUE

Perhaps the most controversial part of any specification for determining the protection afforded a metallic substrate by a paint system is the testing technique. While some advocate total immersion in water or aqueous solutions, others swear by salt spray or moisture condensation tests. Without advocating either procedure we should like to describe some observations which

<sup>3</sup> W. W. Kittelberger, "Water Immersion Testing of Metal Protective Paints—Influence of Bare Metal Areas," *Ind. Eng. Chem.*, Vol. 34, p. 943 (1942).

<sup>4</sup> G. H. Young and G. W. Gerhardt, "Film Continuity of Synthetic Resin Coatings—Test Methods," *Ind. Eng. Chem.*, Vol. 29, p. 1277 (1937).

we made in the course of extensive experiments and which throw some light upon the principles involved in the absorption of water by paint coatings, their blistering and failure to prevent rusting.

Water passes through the face of a paint film under the influence of two forces, osmosis and electroendosmosis. For the purposes of this discussion, osmosis is defined as the transfer of water through a membrane under the influence of a solute concentration gradient, while electroendosmosis is the transfer of water through a membrane under the influence of an electrical potential gradient. In the absence of endosmotic influences, water-soluble material within a paint film, which may be of inorganic or organic nature, causes the formation of an osmosis cell, with the paint film itself playing the role of the semipermeable membrane. Water is pulled into the film and may create enough pressure within or under the film to cause blistering.

If this is correct, paint films should absorb less water and blister less in salt water than in distilled water, for the salt in the bath will compete for the water molecules and the forces which cause the water to penetrate the face of the film will no longer be the osmotic pressure resulting from the presence of the water-soluble material within the film but will be this osmotic pressure minus the osmotic pressure of the salt solution constituting the bath.

That this is so can readily be demonstrated. Apply any given paint—but preferably one of relatively poor water resistance—to several glass panels, and, after allowing them to dry thoroughly, immerse the panels in solutions ranging in salt content from zero to that of sea water (about 3.5 per cent). A periodic check of the weight increase of these panels will reveal that it is an inverse function of the salt concentration of the bath. The effect of this water absorption becomes visible in a short time. While the paint films immersed in the distilled water will blister, the paint immersed in the 3.5 per cent salt solution will remain free of blisters for many months. We have had four glass panels coated with four raw linseed oil primers pigmented with 30 per

cent by volume of zinc yellow, ZTO chromate, red lead, and iron oxide, respectively, immersed in a 3.5 per cent salt solution for almost five years, and the last inspection a couple of months ago showed them to be still free of blisters.

Some may question the validity of this statement, for no doubt they have often seen painted steel panels blister much more severely and rapidly in salt water than in fresh water. What has been said so far regarding blistering applies in this simple form only so long as there is no corrosion. But the suggestion was that glass panels be used to demonstrate the difference between blistering in distilled water and in salt solutions. When a corrodible substrate is used the blistering mechanism is a bit more complicated or, rather, "may be a bit more complicated," for in the absence of corrosion, the blistering mechanism on a corrodible substratum is identical with that on a noncorrodible panel material. However, just as soon as corrosion sets in, the corrosion current flowing between cathodic and anodic areas will superimpose its influence upon that of osmosis, and blistering will be accelerated and intensified. Extensive experiments conducted in our laboratories over the last three years have shown that over 90 per cent of the water absorbed by a painted steel panel coupled to a bare freely corroding steel panel of the same size and immersed in the same bath passed through the face of the film as the result of electroendosmotic influences. The results of our tests highlight the tremendous influence exerted upon water absorption and blistering by electroendosmotic influences which may result from corrosion at pin holes and weak spots in the test film. They emphasize again the necessity of taking the utmost care in the preparation of the test specimens if interpretable results are to be obtained. In addition, they furnish the basis for a plausible explanation of some of the major differences in opinion existing among test engineers with respect to immersion and humidity test methods.

#### HUMIDITY *versus* IMMERSION TESTS

On the basis of our result some would expect that the amount of water absorbed by a paint film de-

creases as the vapor pressure of the immersion bath decreases and that the amount of water absorbed from a vapor would be the same as that absorbed from a solution of the same vapor pressure. In other words, the amount of water present in a paint film at the point of saturation or equilibrium with its environment would be the same regardless of whether the paint film was immersed in the solution or suspended in the vapor above this solution. It has been possible to demonstrate that this deduction holds, but it was found that the rate of water absorption by a paint film is appreciably greater when the film is immersed in the solution than when it is suspended in the vapor above the solution. That means that an immersed panel reaches the point of saturation or equilibrium faster than a duplicate panel suspended in the vapor. Of course, as stated above, this conclusion is valid only in the absence of endosmotic influences which may materially modify the net result observed.

If this reasoning is carried to a logical conclusion, there should be no difference in the amount of water absorbed by a paint film immersed in distilled water or suspended above a water reservoir under conditions of continuous condensation. Many may state that they have observed very marked differences. Although we have not yet had an opportunity to test this experimentally I venture to predict that the differences observed will probably be readily accounted for by temperature differences between the bath and the vapor. The chances are that the vapor itself and the panel suspended in it were close to 100 C. while the bath used in the comparison test was most likely kept at room temperature. Doty, Aiken and Mark<sup>5</sup> were able to show that the moisture permeability of a high polymer film doubles with a temperature rise of about 10 C. It would seem reasonable to assume that a similar temperature effect is operative in the case under discussion here. Therefore, we believe that a paint system will absorb the same amount of water regardless of whether it is suspended in water vapor under

conditions of continuous condensation or immersed in distilled water at the same temperature. If this relationship could be proved experimentally some testing procedures could probably be simplified considerably. Humidity cabinets which are meeting with so much favor among paint test engineers are difficult to maintain and to control. It would seem simpler to replace such cabinets with immersion baths of comparable temperature and vapor pressure.

This applies with particular emphasis to the salt spray test. The use of the salt solution decreases the water absorption of the paint film due to osmosis, and hence decreases markedly the rate of blistering as long as the film remains unbroken. Just as soon as the film is ruptured, however, electroendosmotic influences will predominate and both the water absorption by the film and the corrosion of the bared substrate will proceed at an accelerated rate. But we are unable to see in what respect a salt spray test offers any significant advantages over a simple immersion test in a bath of the same vapor pressure and the same temperature.

The second step referred to earlier, the actual development of an instrument or technique or both, is nothing more than a logical application of the basic principles developed in the first step. It involves merely the detailed description of the techniques to be used in the preparation of the substrate material, the application of the test paint, and the testing of the specimen to insure that the conditions indicated to be necessary in the first step actually prevail. This phase of paint testing is too well known to require further discussion at this time.

#### TRANSLATION TO PRACTICE

However, in many cases, the third of the three steps listed, the widespread use of the testing method to establish its parallelity with actual service experience, is not fully appreciated and will therefore be discussed at some length. As a disinterested observer, I have frequently been struck by the lack of agreement among experienced paint testing engineers regarding the practical value of test results and especially about their interpretation in terms

<sup>5</sup> P. M. Doty, W. H. Aiken, and H. Mark, "Water-Vapor Permeability of Organic Films," *Ind. Eng. Chem., Anal. Ed.*, Vol. 16, p. 686 (1944).



of actual service, and I have gained the impression that many of the differences could readily be resolved.

Let us assume that reproducible and significant results have been obtained in a number of laboratory tests. The question, then, is what do these results signify in terms of length of life and protection the paint system offers under conditions of actual service? In the twenty years that I have spent in the paint industry I have come to the conclusion that there is no substitute for actual experimentation and experience when it comes to translating laboratory test results into terms of durability. The problem is the evaluation of the test method and the only way this can be done is to subject a sufficient number of paint systems simultaneously to the laboratory test and to actual service tests until a sufficiently large mass of related data has accumulated to serve as a basis for deriving a translation factor. Many disagreements between paint testing engineers may be traced to the fact that each one has his own idea regarding the practical value or durability of the so-called standard paint systems. On closer analysis it will usually be found that the disagreeing paint testing engineers have a fixed mental picture of the value of the standard of comparison derived from a very

few paint service tests or experiences which happen to have made a lasting impression upon their memories. In my opinion it is the major problem of the third or proving-in stage of the development of any standard test apparatus or procedure to fix the true value of the standard comparison paints.

The magnitude of this job becomes apparent when it is fully realized that in most service tests it is impossible to control either the nature and the preparation of the substrate or the conditions of application and service within the limits necessary for reproducibility within even tolerable limits. As a result of this condition any one service test may rate a given paint good, intermediate, or bad depending on a more or less accidental combination of factors. Therefore, it will be necessary to seek a solution for this problem on a statistical basis. On the face of it, this seems like a herculean task doomed to failure before it is begun. However, similar and possibly more difficult, problems have been solved successfully. The similarity between the problem of predicting the life expectancy of a human being on the basis of mortality studies and the problem of predicting the life expectancy of a paint film on the basis of service tests is apparent. A study of life

insurance methods and an attempt to apply the laws of probability to paint testing may prove quite helpful. Although unable to predict accurately the probable life expectancy of an individual, a life insurance company can predict with reasonable accuracy the average length of life under predetermined conditions of a certain class of people characterized by certain physical makeup, certain habits, and certain environment. This exactly is the basic idea behind service testing: namely, to predict the average length of life of a certain type of paint under known conditions of exposure or use. After suitable standard paints have been selected on the basis of extensive service tests it is only necessary to include several specimens of each in every test series to be able to grade the experimental paints as to their probable life expectancy and performance value.

All of this may seem like a lot of trouble for a paint test, but really it is no more trouble than trying to interpret some of the results obtained when these precautions are ignored. Our experience has convinced us that any efforts to make certain that the observations made, really are a function of some inherent property of the test paint are well worth-while.

#### Mr. W. W. Cranmer<sup>1</sup> (prepared discussion)

During May, 1945, our laboratory placed 200 panels on tide range exposure at Miami, Fla. These panels were in 20 groups, with 10 presumably identical panels in each group.

Figure 1 illustrates the variation in rusting shown by one of these groups after three months' tide range exposure. Figures 2, 3, 4, and 5 show other groups from the same series. Figure 6 is identical with Fig. 5 but shows the group after six months' exposure. Failure is more extensive, but the variation in results is of the same order.

Figure 7 shows four of the groups arranged for comparison. By selection of individual panels, it would be

<sup>1</sup>Industrial Test Laboratory, Philadelphia Naval Shipyard, Philadelphia, Pa.

#### DISCUSSION

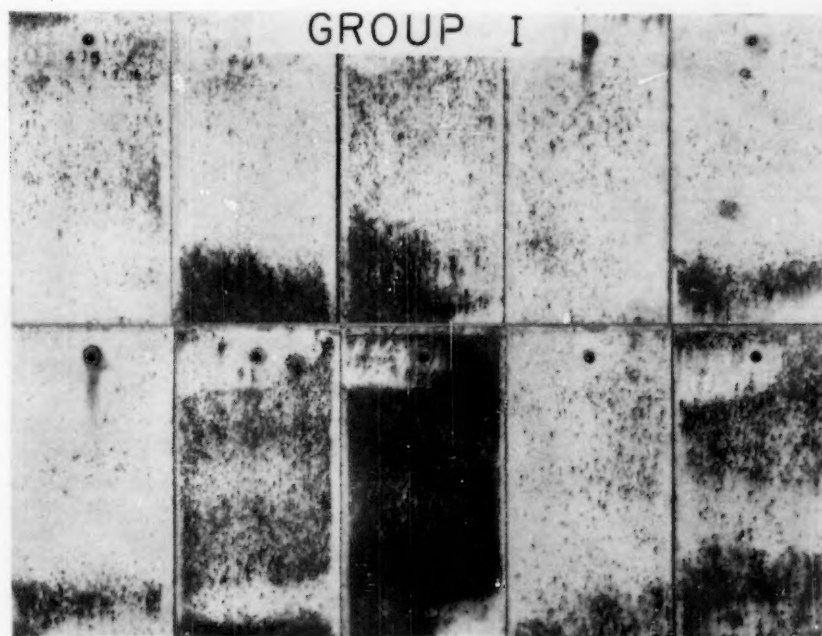


Fig. 1. Three Months' Tide Range Exposure of 10 Duplicate Panels.

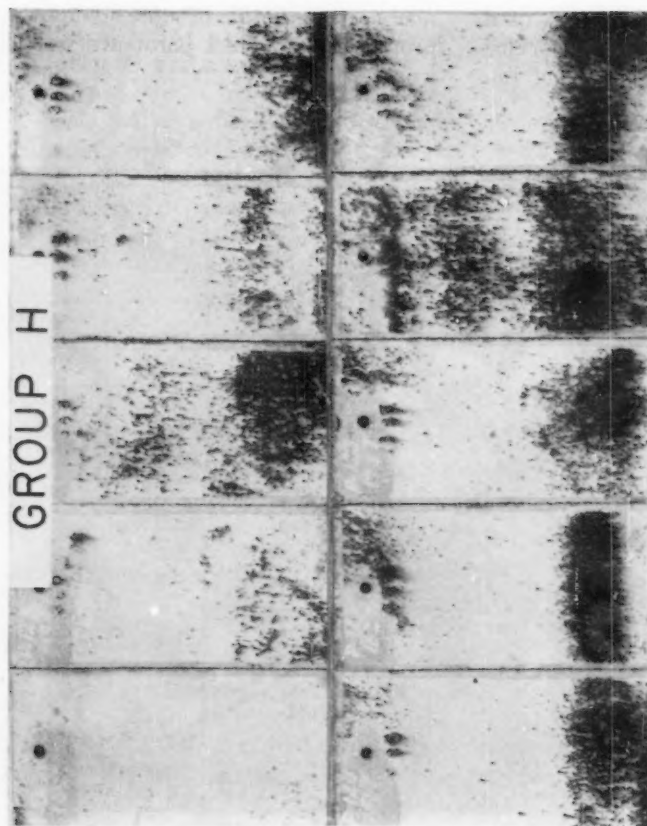


Fig. 2.—A Second Group of 10 Duplicate Panels after 3-Months' Tide Range Exposure.

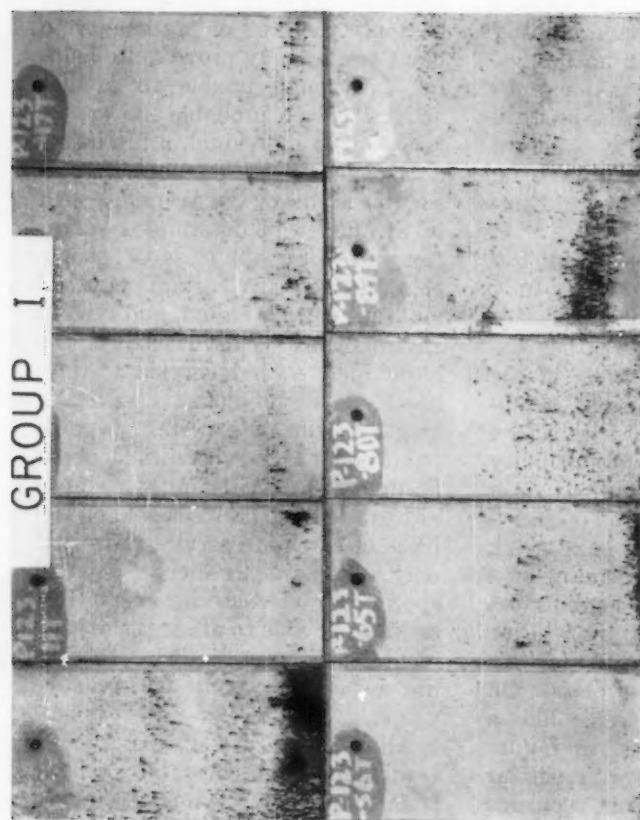


Fig. 3.—A Third Group of 10 Duplicate Panels after 3-Months' Tide Range Exposure.

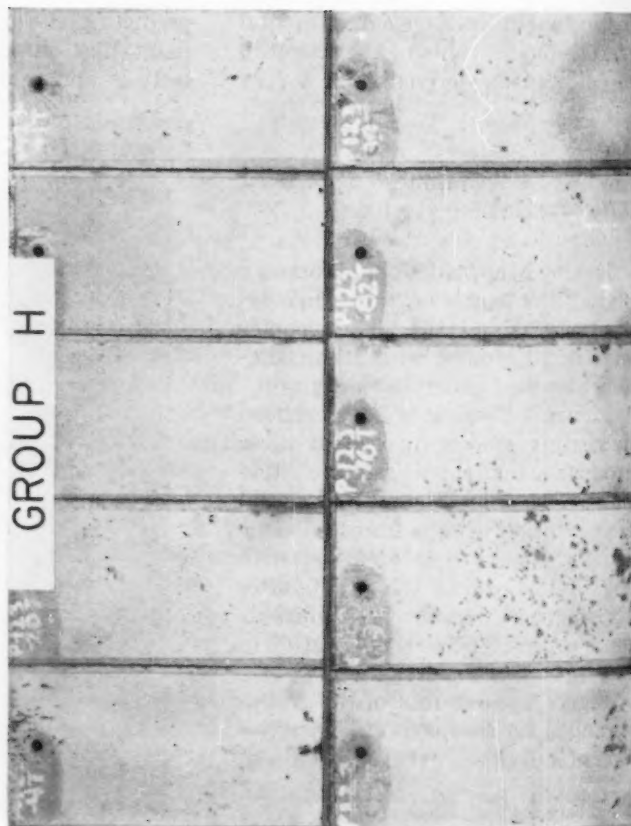


Fig. 4.—A Fourth Group of 10 Duplicate Panels after 3-Months' Tide Range Exposure.

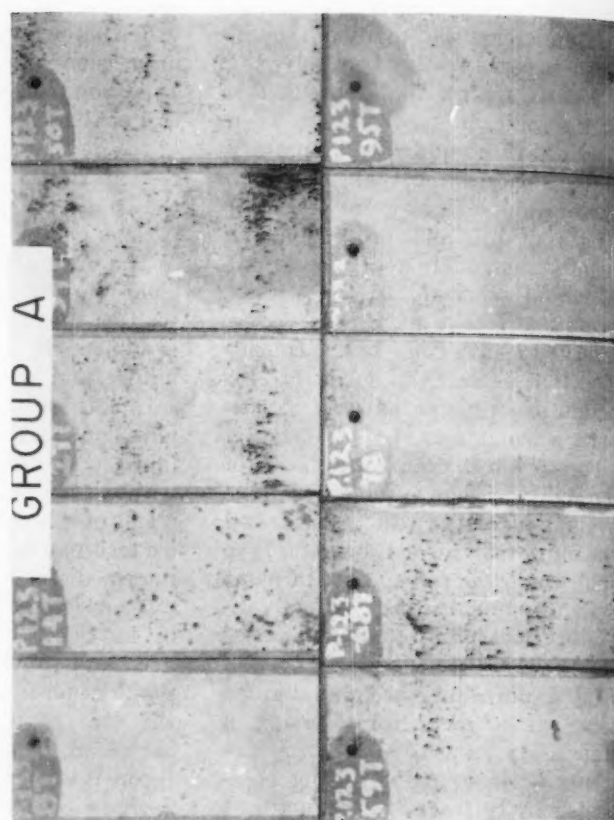


Fig. 5.—A Fifth Group of 10 Duplicate Panels after 3-Months' Tide Range Exposure.



## GROUP A

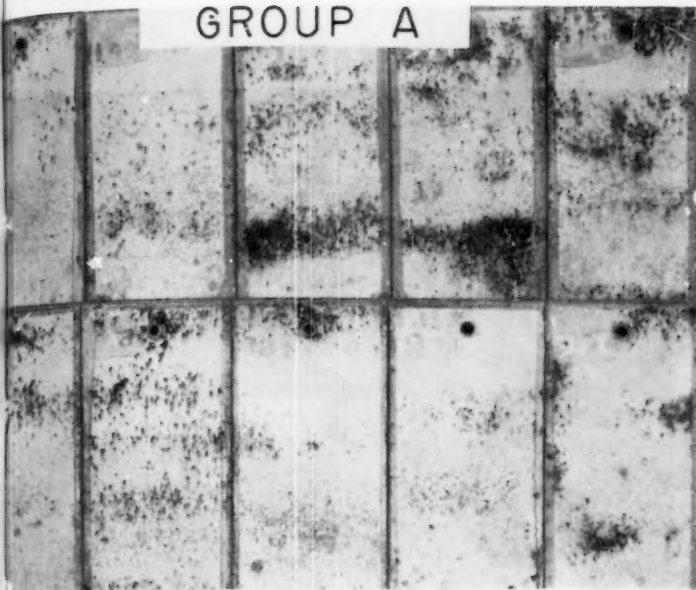
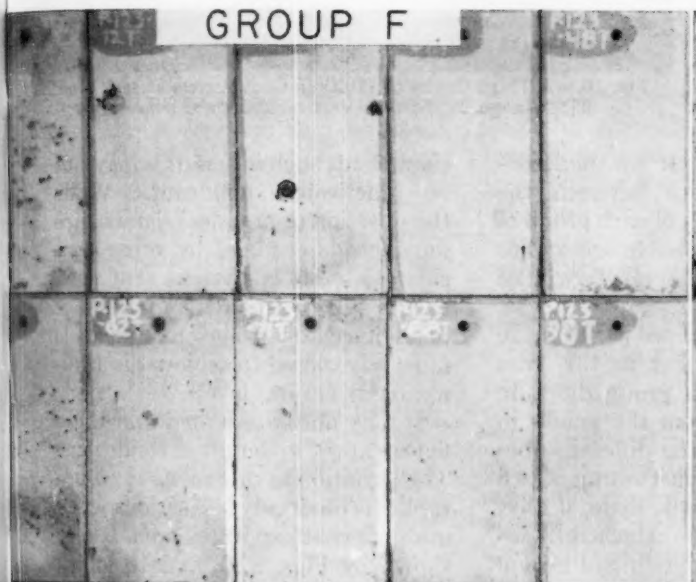


Fig. 6.—The Same Group of Panels Shown in Fig. 5 After 6 Months' Tide Range Exposure.

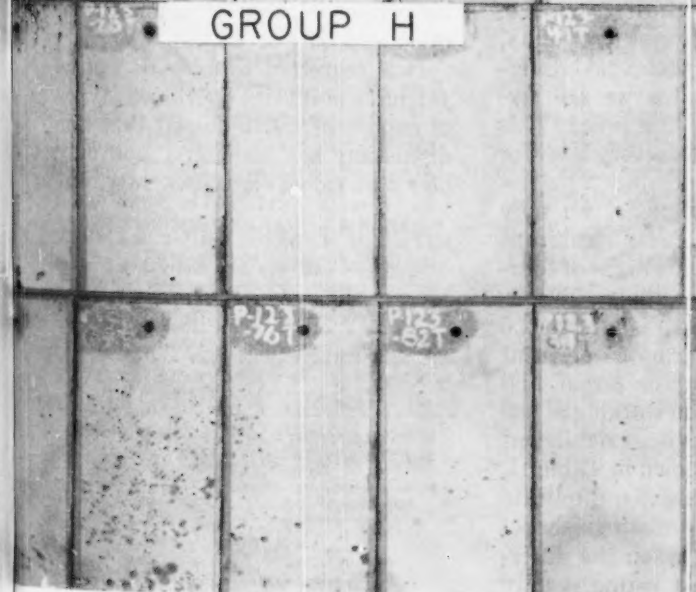


Fig. 8.—A Group of Multiple Coat Panels after 6 Months' Tide Range Exposure. Vertical Pairs are Duplicates.

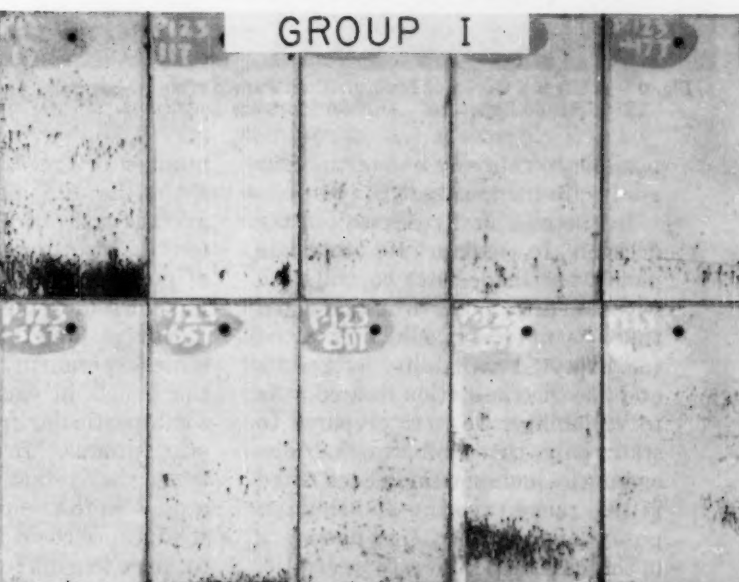
## GROUP F



## GROUP H



## GROUP I



## GROUP J

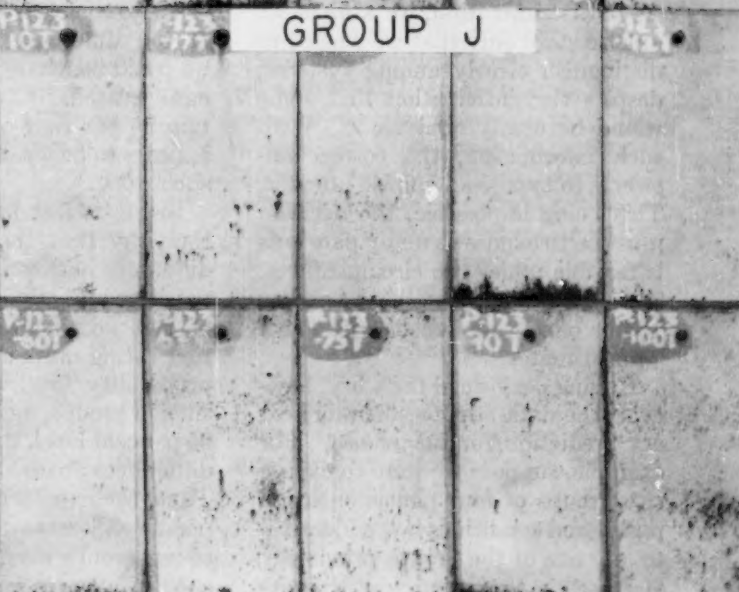


Fig. 7.—Four Groups of Panels Arranged for Comparison—Weathered.

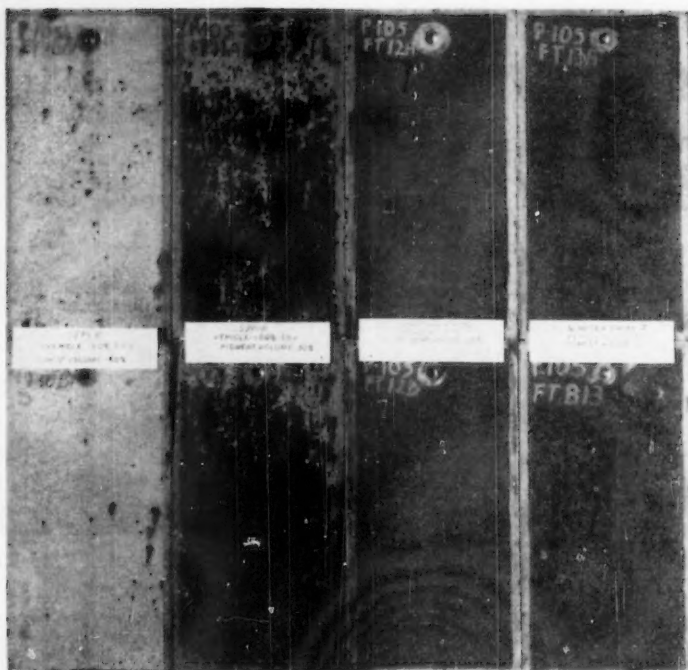


Fig. 9.—A Second Group of Multiple Coat Panels after 6 Months' Tide Range Exposure. Vertical Pairs are Duplicates.



Fig. 10.—A Third Group of Multiple Coat Panels after 6 Months' Tide Range Exposure. Vertical Pairs are Duplicates.

possible to rate any one of the four groups, in turn, as best.

In the case under discussion, the decision to expose 10 duplicate panels was made after consultation with a statistician, who indicated that the number would depend on the expected variability of results and the discrimination desired. As to variability, we were prepared to state only that embarrassing discrepancies had sometimes been noted in tide range exposure and that exposure of a single coat, as necessary in this case, was known to be erratic. As to discrimination, we were again able to state only that we wished to distinguish clearly among systems, despite the anticipation that some would be nearly equivalent. With such information, the correct answer is to expose an infinite number. This being impossible, the decision must be to expose as many panels as is feasible under the circumstances. Thus the original decision to expose 10 like panels may be described as a "guesstimate."

Having performed the work, however, the data now permit more exact prediction for future use. For example, suppose we were to expose two groups of four panels each, all panels and conditions being identical to any one of the groups previously discussed. Again, suppose this experiment to be repeated a large

number of times. If we then consider the difference between the average rust ratings of each group of four panels, the probable occurrence of purely chance differences will be as shown in Table I.

Now assume that we perform the same experiment, but in this case the panels in each group differ in some particular from the panels in other groups. If the difference between the average rust rating of two groups were one unit, little, if any, significance could be attached thereto, since this difference might be due solely to chance one third of the time. If the difference were two units, we could conclude that a real difference existed. Of this we are certain 95 per cent of the time. This appears to be a satisfactory level for such work.

In statistical language, we may then say that the least significant difference between averages of four-panel groups, under the conditions of this specific test, is about 2.0 rust rating units at the 95 per cent probability level. For larger and smaller groups, again working at the 95 per cent level, the least significant differences are as shown in Table II. Thus, the exposure of ten duplicate panels will serve to distinguish between groups even when the difference in average rust rating is only about one unit. While statistically

significant, such differences may not be practically significant. While the question of practical significance must be determined by other considerations, it is obvious that data of this type will allow us to predict in advance exactly how many panels must be exposed to achieve discrimination at various levels.

It may not be assumed that these figures apply under other conditions. The variation in tide range exposure results is obviously less serious when multiple coat exposures are made as shown by Figs. 8, 9, and 10 which have been selected at random from other exposure series.

It is regretted that we do not as yet have statistics on various types of exposures. It is hoped that this discussion has indicated not only how tide range exposures vary, but

TABLE I.—CHANCE DIFFERENCES BETWEEN AVERAGE RUST RATINGS. (Groups of Four Identical Panels.)

| Differences | Occurrence, per cent |
|-------------|----------------------|
| >0.5.....   | 60                   |
| >1.0.....   | 35                   |
| >1.5.....   | 10                   |
| >2.0.....   | 5                    |
| >2.5.....   | 1                    |

TABLE II.—LEAST SIGNIFICANT DIFFERENCES BETWEEN AVERAGE RUST RATINGS.

| Averages of | Approximate LSD* |
|-------------|------------------|
| 10.....     | 1.0              |
| 5.....      | 1.5              |
| 4.....      | 2.0              |
| 2.....      | 2.5              |
| 1.....      | 4.0              |

\*95 per cent probability level.



also how statistical studies may be of value both in the design of test and evaluation of the data.

The assistance of M. Kaplan of this laboratory, who supplied all statistical data, is gratefully acknowledged.

The opinions expressed are those of the author, and do not necessarily represent the opinion of the Navy Department.

MR. T. R. DONLAN.<sup>2</sup> How did you clean the panels?

MR. CRANMER. We were trying to evaluate methods of surface preparation. Therefore, each group of ten panels was cleaned by a somewhat different method. There is no comparison of paints in the test since the same paint was applied to all the panels. The comparison is between methods of surface preparation and they involve such things as phosphoric acid treatments, dichromate and phosphoric acid, sulfuric acid, descaling, plus lime rinsing, etc.

MR. E. J. DUNN, JR.<sup>3</sup>—Is there some set procedure that you followed in this statistical summary? I wonder how you could get so complete an analysis with so few panels.

MR. CRANMER. I was afraid somebody would ask a question like that. I am not a statistician, therefore I should suggest that any questions concerning the statistics be directed to M. S. Kaplan at our laboratory.

[Since the meeting the following explanation has been received from Mr. Kaplan by the author.

I assume that by statistical summary you refer to Tables I and II. It should be made clear in practice that such tables cannot be drawn up on the basis of a single exposure of 100 panels. To obtain a good measure of chance differences which might be expected between panel rust ratings under a given set of exposure conditions, it is necessary to expose many sets of panels in order to build up a reliable body of experience. The tables were prepared on the assumption that

the uniformity or reproducibility obtained from 100 panels originally exposed would prove reliable. If this assumption is taken as true then the tables may be calculated by elementary statistical methods described in texts on the subject. No claim is made, however, that the values obtained in the particular experiment are reliable for prediction as to what might be expected. For interpreting the particular experiment, however, they can be used.]

MR. T. R. DONLAN<sup>4</sup> (*prepared discussion*)

During the 1941 meeting of Subcommittee VII of Committee D-1, the question arose as to whether spot or partial sanding of steel test panels would adversely affect the life of the finished coat. The Army Ordnance wished to prepare specifications dealing with the reclaiming of used as well as rusted panels and the question, therefore, was brought forward at that time.

A cooperative test group was established at the February, 1944, meeting and the following program agreed upon:

(a) Naphtha degreasing *versus* vapor degreasing.

(b) Spot sanding *versus* full sanding, *versus* no sanding on degreased panels.

Six panels were used for each test and all panels were cleaned in the same manner by the various cooperators. Each was assigned certain accelerated exposure tests depending upon available equipment. Accelerated tests consisted of:

(a) Distilled water immersion at 77 F.

(b) Tap water immersion.

(c) Humidity cabinet.

(d) Salt spray.

(e) Salt solution (20 per cent NaCl) immersion.

Outdoor exposure tests also were run for check purposes.

The panels conformed to requirements of A. S. T. M. Tentative Method for Preparation of Steel Panels for Exposure Tests of Enamels for Exterior Service (D 609-42 T)<sup>5</sup> for cold-rolled steel panels.

<sup>2</sup> Chemist in Charge, Solvents Development Lab., Standard Alcohol Co., Elizabeth, N. J.  
<sup>3</sup> 1944 Book of A.S.T.M. Standards, Part II, p. 1558.

Spot and full sanding were carried out by sanding the lower half of each panel to a bright finish and spotting the upper half using a five spot pattern.

Panels were coated 1 mil thick with Ordnance Department Specification AXS-750 Primer and 1 mil with AXS-752 enamel. All but one cooperator edge-coated as supplementary protection.

The data showed variations too complicated to be covered in the present discussion. Attention, therefore, is directed to the official report by Subcommittee VII of Committee D-1 to be published in the current *Proceedings*.

Results, however, can be summarized as follows:

1. The six panels in each set, in general, checked quite well.

2. Spot sanding on the upper and full sanding on the lower part of the panel resulted in localized blistering and rusting not necessarily on the sanded areas. Failure, apparently, is governed by the type of accelerated exposure combined with the method of cleaning.

3. The presence or absence of supplementary edge coating seemed to influence the location of rusting, that is, whether rusting occurred on the sanded or unsanded portion.

The importance of a uniformly treated surface on steel panels for immersion tests of paint systems was evident throughout.

MR. V. M. DARSEY<sup>6</sup> (*prepared discussion*)

Early work of the members on the Panel Preparation Group of Subcommittee VII reveals that, in addition to the cleanliness of steel, its surface finish influences the performance of applied paint coatings. Any method of preparation which changes the surface characteristics of the metal is likely to have a definite effect on the adhesion and resultant durability of applied paint coatings. For this reason a method of surface preparation which did not materially change the surface characteristics of the metal was recommended for cleaning steel panels prior to painting.

<sup>6</sup> President, Parker Rust-Proof Co., Detroit, Mich.

<sup>4</sup> Chemist in Charge, Solvents Development Lab., Standard Alcohol Co., Elizabeth, N. J.  
<sup>5</sup> National Lead Co., Brooklyn, N. Y.

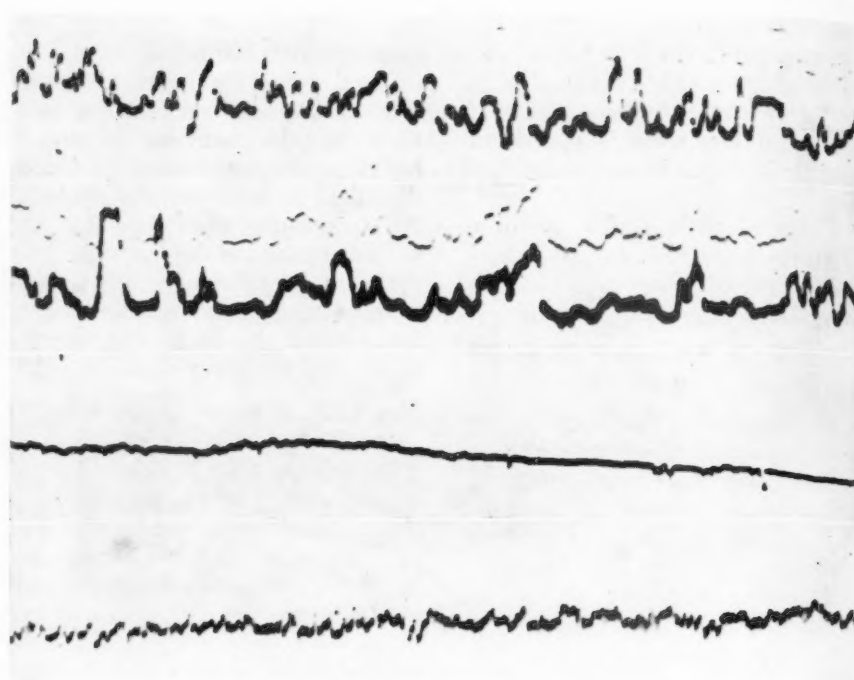
One of the major problems in specifying a suitable steel panel for paint tests is that of a uniform surface finish. Objection was raised against the use of full-finished cold-rolled steel because of the poor adhesion of paint applied thereon. Originally it was suggested that a type of steel finish such as produced by sand-blasted rolls be used which would provide better paint adhesion. Samples of steel panels secured from different sources with this type of finish were found to vary considerably in roughness, which was undesirable. In order to provide a more uniform steel finish, this problem was discussed with A.S.T.M. Committee A-1 on Steel, which committee advised that the No. 5 dull finish as produced by the Carnegie-Illinois Steel Corp. would be the most uniform type of surface commercially available. This type of steel finish is now recommended for use in preparing panels for paint testing by A.S.T.M. Tentative Method D 609.

**Mr. William F. Singleton<sup>7</sup> (prepared discussion)**

One important consideration in testing by humidity or immersion is the choice of a steel panel having a uniform surface of the requisite activity in regard to corrosion. In A.S.T.M. Tentative Method of Preparation of Steel Panels for Testing Paint, Varnish, Lacquer, and Related Products (D609-45 T)<sup>8</sup> there is a description of cold-rolled steel for panels which represented an agreement on a commercially available uniform surface finish. However, there had been less consideration given to the activity in regard to corrosion than to the physical roughness. In this connection, an experiment has been carried out on the effect of the surface condition of steel panels in immersion testing. The experiment concerns two variables, the roughness of the rolled surface and the practice of sanding the panels.

Specification D 609 now calls for a satin finish equivalent to Carnegie-Illinois No. 5. Such a surface is visibly rough. For the experiment, a similar type of steel was on hand,

<sup>7</sup> Philadelphia Laboratory, E. I. Du Pont de Nemours and Co., Inc., Philadelphia, Pa.  
<sup>8</sup> 1945 Supplement to Book of A.S.T.M. Standards, Part II, p. 192.



**Fig. 11.—Surface Roughness of Cold Rolled Steel.**

Original Magnification: Vertical 5400 Times, Horizontal 87 Times (reduced 1/2 in reproduction)  
Top section—Carnegie-Illinois No. 5 Satin Finish as Specified in D-609.  
Second section—"Rough" Steel (see text).  
Third section—No. 2 Finish Parallel to Rolling Direction.  
Bottom section—No. 2 Finish Perpendicular to Rolling Direction.

except that the surface was slightly coarser. This may be called "rough" steel to distinguish it from a second type of steel which may be described as "smooth." The latter, strip steel with No. 2 finish, is smooth enough to give a somewhat diffuse mirror reflection. It has parallel microscopic ridges formed by the machining marks on the finishing roll, as compared with the random peaks and hollows in the "rough" steel.

To characterize the surfaces more exactly, profilograph tracings were made (Fig. 11). From the tracings the average roughness in micro-inches from peak to valley and the frequency in waves per inch were calculated. The data are presented in Table III. Each surface was also rated according to the General Electric roughness standards, as shown in the last column of the table.

Each steel was prepared for painting by two methods. The first, corresponding to Procedure A of D 609 consisted of five operations:

- (a) Vapor degreasing with trichlorethylene.
- (b) Wiping with a cloth dampened with petroleum naphtha to remove the insoluble residue.
- (c) Wiping with dry muslin.
- (d) Immersion in isopropyl alcohol for 1/2 hr.
- (e) Drying 1/2 hr at 150 F.

The second method was by sanding:

- (a) Vapor degreasing with trichlorethylene as before.
- (b) Sanding with No. 240 emery paper until the surface was uniform and all scratches and surface imperfections had been removed.
- (c) Polishing with No. 400 emery paper to a mirror surface.
- (d) Wiping with a clean cloth

**TABLE III.—ROUGHNESS OF STEEL PANELS.**

| Panel                                | Description   | Profilograph                                  |                                   | General Electric Roughness Standard |
|--------------------------------------|---|---|-----------------------------------|-------------------------------------|
|                                      |   | Average Roughness Peak to Valley, microinches | Average Frequency, waves per inch |                                     |
| Revision of A.S.T.M. D 609-45 T..... | Satin finish equivalent to Carnegie-Illinois No. 5          | 98  | 270                               | D                                   |
| Rough.....                           | Similar to revised D 609-45 T, but coarser                  | 124   | 104                               | E                                   |
| Smooth.....                          | Cold-rolled strip steel No. 2 finish across machining marks | 45  | 750                               | C to D                              |
|                                      | With machining marks  | 17  | ...                               | ...                                 |



dampened with petroleum naphtha to remove the debris from the sanding operations.

All panels received a two-coat automotive paint system the same day they were cleaned, consisting of 0.5 mil of baking primer followed by 1.5 mils of a baked gloss topcoat. The panels were aged one week at room temperature. They were then tested by partial immersion in a bath of distilled water at 98 to 100 F. Each system was exposed in triplicate.

The results are presented in Table IV as the days to failure by blistering for each panel and as an average for each system. The reproducibility is good for most systems, and in all cases the difference between systems is larger than any panel variation.

The effect of surface condition on the rate of failure is found to be surprisingly large. The weakest system, on solvent cleaned rough steel, fails five times as fast as the

TABLE IV.—EFFECT OF SURFACE CONDITION ON BLISTERING.

| Steel       | Cleaning Method | Days to Failure | Remarks              |
|-------------|-----------------|-----------------|----------------------|
| Rough.....  | Sanded          | 15+             | Excellent at 15 days |
|             |                 | 15+             |                      |
|             |                 | 15+             |                      |
| Smooth..... | Sanded          | 15+             |                      |
|             |                 | 15+             |                      |
| Smooth..... | Solvent cleaned | 8               |                      |
|             |                 | 8               |                      |
| Rough.....  | Solvent cleaned | 5               |                      |
|             |                 | 2               |                      |
|             |                 | 2               |                      |

systems on sanded steel. The data support two conclusions:

1. Sanding greatly alters the surface and delays the appearance of blistering. In this test, the sanded rough steel produced somewhat slower blistering than the sanded smooth steel.

2. For solvent cleaned steel, the rough surface produces faster blistering.

A tentative explanation of the effect of sanding is suggested by a further experiment which is too incomplete to report in detail. An attempt to measure the surface activity by a modified Mears test indicates that the sanded surfaces are less corrodible than those which are solvent cleaned. This is the opposite of what had been expected on the assumption that sanding would insure a fresh surface of metal. Actually, it may be suggested that

thorough sanding, as in the present experiment, may contribute to the formation of an oxide coating which is substantial enough to influence the rate of blistering of paint applied over it. Considerable mechanical work is done during the process of sanding, and the local heat which is developed may result in a heavier and more continuous coating of oxide than is present originally. The fact that the final sanding is carried out with a fine grade of emery paper would be more favorable to the formation of a continuous coating than ordinary procedure where a coarser grade is used. The superiority of the "rough" steel over the "smooth" steel after sanding on this hypothesis would be the result of the greater work which must be done to sand the original surface to a smooth finish.

It appears that the satin finish steel now specified in Method D 609 represents an active surface, both because the steel has a rough finish and because it is solvent cleaned without sanding. Results obtained from humidity or immersion tests on this steel should not be compared directly with previous results obtained on steel with a different surface finish.

#### Mr. C. C. Hipkins<sup>9</sup> (prepared discussion)

There are some who feel that the Pangborn test panels prescribed in A.S.T.M. Tentative Method D 609<sup>8</sup> are too rough, particularly for testing enamels. As a result, a compromise has been proposed to employ steel panels in accordance with A.S.T.M. Standard Specifications for Cold-Rolled Strip Steel (A 109 - 38)<sup>10</sup> having a No. 5 (dull) finish, as produced by the Carnegie-Illinois Steel Corp., or equal. There are others who feel that this proposed panel is too smooth a surface for paint testing purposes. Actually, the roughness is about that of standard C in the General Electric series which has an equivalent roughness of approximately 16 microinches when measured by a profilometer and which, relative to a cold-rolled furniture steel, could be considered quite rough. In my opinion, the matter of whether a surface is con-

sidered too rough or too smooth is largely influenced by the type of surface one has been accustomed to employ for test purposes.

Let us examine the matter of just what is needed. The paint technologist must be concerned with the surface condition of test specimens because of its relation to the adhesion of the finish to the substrate. The bond of a film to a surface is made up of two forces, one of which is mainly physical and depends upon the surface contours of the metal and the second is intrinsic adhesion which is more physico-chemical in nature and is a function of the attraction between the molecules of the metal and the molecules of the film.

As is well known, the mechanical roughening of the surface, such as by sand or grit blasting, provides a surface which in general insures a high order of adhesion. This treatment makes for uniformity of surface by removal of contamination, oxide coatings, etc. In addition, it also extends the actual area per unit of macroscopic area so that there becomes a greater number of molecules available at the paint-panel interface to which the molecules of the film-forming materials may attach themselves. Further, blasting also provides many tiny facets of metal inclined at various angles into which the film can physically key itself. Profilometer measurements made at our laboratories employing a finely pointed diamond stylus for following the contours of a surface and an optical lever system for magnifying the undulations of the stylus as it rides over the surface under examination, lead to calculations that in some instances showed the increase in surface area to be at least 20 times. With changes of this magnitude in surface area, it is not at all surprising that blasting of surface increases adhesion to the extent that it does.

While blasting the surface of a metal makes it uniform, care is necessary to maintain that uniformity since it has been observed that it is merely a matter of minutes before the surface may change by oxidation and contamination from the atmosphere. This illustrates the desirability of minimizing the interval between the surface prepara-

<sup>9</sup> Bell Telephone Laboratories, New York, N. Y.  
<sup>10</sup> 1944 Book of A.S.T.M. Standards, Part I, p. 96.

tion and the coating if controlled uniformity of specimens is a factor in any particular set of tests.

From what has been said, it is at once apparent that the surface condition is an important adjunct of the finishing system, and it therefore follows that the only way to be certain that a particular film would adhere to a particular surface would be to follow the obvious method of testing that finish on that surface in a statistical manner. This is akin to the actual service approach to the problem of testing such as discussed by Mr. Elm.

However, where the properties of a protective coating are to be evaluated independent of the type of surface, or where the exact surface on which the finish is to be applied is not predictable, the more empirical type of approach to the problem can be followed by using an arbitrarily selected specimen on which to perform the tests. In these cases it really would not matter whether the Pangborn or the new proposed panel were used provided that either surface is uniform and readily duplicable and also that the results obtained are related to the surface on which the tests were performed.

I should like to caution against the hazard of expanding the results obtained in testing on one surface to predict the qualities of the same finish on a surface that may be considered but slightly different. To illustrate this point, some years ago we were startled by the wide differences in adhesion obtained on two brass surfaces. Our tests were conducted on rolled brass sheet, which most of us would consider a smooth surface, and the adhesion of the finish was very good. However, when this finish was applied to brass parts made by a heading operation, its adhesion was surprisingly poor. Such a difference would not have been predictable on the basis of examination of the two surfaces since visually, at least, they were very similar.

Therefore, even when a finish has been found to possess a high order of adhesion to a given surface, it is advisable to check the adhesion on the particular surface to which the finish is to be applied to insure satisfactory durability of the finish.

#### Mr. Ralph J. Wirshing<sup>11</sup> (*prepared discussion*)

We take no exception to any of the statements made by Mr. Elm. We realize, probably as well as anyone, that the preparation of test panels in the laboratory is a task that is difficult, time consuming, and requires considerable care if the results are to be of any value. This is due to the many variables, which include variations in the base metal, methods of cleaning, viscosity of the paint, temperature of the paint, method of application, thickness of film, type of undercoats used, baking times and temperatures, the amount of sanding or polishing of the topcoat, and probably others.

We agree with Mr. Elm that the preparation of the sample panel is of great importance, but we feel that it would be a physical impossibility to check each panel in any manner so as to be able to guarantee that each spot on the panel is the same as every other spot on the panel. While some chemical tests might be devised to insure this fact, the surface of the panel would thereby be changed and would no longer be satisfactory for the test. It is equally impossible to insure that panels in any series are uniform in all respects.

We are in the fortunate position of having very complete service data on a large number of paint materials since we have millions of cars in service under a wide variety of climate conditions. For this reason we can always have a standard material with which to compare the sample under investigation. In every case such a standard is included in the test.

Panels are prepared for test in the same manner in which the part is prepared in production. For example, if the material is to be used on phosphate-coated steel, the panels are given a phosphate coating; if the material is to be used over a dip-coated primer the panels are dip-coated in the primer; if the material is to be used over an alkali cleaned steel the panels are alkali cleaned. As a matter of fact, in many cases the test panels are run through the production line to insure that they

receive the identical treatment the metal will receive in production.

Mr. Elm mentions coating the edges of panels with some protective coating such as wax. In automotive production, rusting from the edges is critical, so tests with large edge effects are most interesting and we do not protect the edges of test panels.

The use of the immersion test instead of the humidity test would probably be satisfactory, but would be somewhat more difficult for us since we subject production pieces, including fenders and entire automobile bodies, to the same tests we use on panels.

We try to minimize the effect of some of the variables by preparing several panels of each material and by repeating the whole series several times.

While we are not sure that Mr. Elm is referring to the type of test work we are doing, nevertheless, we do feel that he is proposing an ideal set of conditions which it would be impossible for us to obtain in our work.

#### Mr. M. Van Loo<sup>12</sup> (*prepared discussion*)

Mr. Elm has pointed out that to avoid misleading results in laboratory test procedures the panels used in the test must be uniform. This means that the ideal situation calls for uniformity not only over the entire surface of each panel, but also uniformity panel to panel throughout the entire group in the test. It becomes obvious immediately that we must not only specify the nature of the steel panels, but we must also make certain that prior to the application of the coatings under test the panel surfaces are uniformly free from oil, grease, rust and foreign matter. Method D 609 calls for new prime cold-rolled steel that has been oiled at the mill, and therefore methods of removing this oily coating must be considered.

Usually the oil coating on such cold-rolled steel is of a paraffin-base type, sometimes with lanolin, fatty acids, sulfonated compounds or other wetting agents added. There will always be some dirt or other foreign matter present in the oily

<sup>11</sup> General Motors Research Laboratories, Detroit, Mich.

<sup>12</sup> Director of Paint Research, Sherwin-Williams Co., Chicago, Ill.



film. Whatever coating there is must be removed completely so that a uniform metal surface is obtained such as is usually defined as "chemically clean." Recommendations have been set up for metal cleaning requiring that the degree of cleanliness be determined by the ability of the surface to support a film of water break-free.

When methods of cleaning the metal surface were considered, alkali cleaning, a very popular commercial method, was not included in the test procedure. Considering the very wide variety of such cleaners which might be used, there may be some difficulty in accomplishing the removal of all traces of residual alkali.

To prevent any chemical change in the character of the steel surface, only volatile solvents which are unreactive with the metal surface are used. The procedure for cleaning the test panels in a suggested revision of Tentative Method D 609-45 T recommends the use of a grease solvent consisting of a mixture of three parts by volume V. M. and P. naphtha and one part monoethyl ether of ethylene glycol. It is reported that this combination has been found most satisfactory for removing oxidized films and foreign matter. It was originally intended that the method call for cleaning by scrubbing with a brush or lint- and size-free cloth followed by wiping dry with a clean cloth. The cleaning proceeded through the use of this solvent mixture, without resorting to sanding or abrasion of the surface, until the panel would support a water film break-free when immersed in distilled water.

This portion of the method deserves further discussion. At least one possible interpretation of the method in its original form was that the cleaning may and can be done entirely by solvent wiping to the point where the surface will support a break-free water film. Since the oil or other surface soil on the panels may vary widely in character and therefore in ease of removal, it is possible to clean some panels by this method to the point where they will support a film of water break-free over substantially the entire surface of the panels. In the case of our own laboratory stock of panels

however, it has not been possible to do so without expenditure of time and effort which we consider excessive, particularly when a large number of panels are used in a given test. Furthermore, there is usually a wide variation in the degree of uniformity of cleanliness and of surface activity of the panels, which is contrary to our original concept of conditions required for laboratory test procedures.

It would appear that any solvent scrubbing or wiping as ordinarily conducted is immediately accompanied by some surface contamination. It is impractical to provide a continuous supply of clean cloth and clean solvent so that the contaminated cleaning cloth never travels back over the cleaned areas.

Vapor degreasing with trichloro- or perchlorethylene would eliminate many of these objections since if properly executed the metal surface is cleaned with fresh pure condensed solvent. Sometimes it is found desirable to include some jet cleaning to remove insoluble dirt particles which cannot be removed without some mechanical force. We have found that panels degreased with trichlorethylene vapor will support a film of water break-free in spite of the obvious presence of mechanical dirt or smut. This deposit should be wiped off, however, if the panel is to be used for laboratory tests.

Usually, in commercial practice, if the shape of the article being cleaned is such that proper washing action is obtainable, solvent vapor degreasing is very satisfactory. However, because laboratory scale apparatus is not always available for such cleaning, because some experience and care is required in handling the solvent, and because of some apprehension as to possible activation of the metal surface, it was originally decided not to suggest trichlorethylene or perchlorethylene vapor degreasing as an alternate cleaning method for preparing steel panels for the laboratory testing of organic coatings. It is now being considered as an alternate method of cleaning to be included in the recommended method.

A proposed revision of Method D 609 that has been under discussion states that after the initial sol-

vent scrubbing, "The panels shall then be further cleaned . . . by the use of this solvent mixture until each panel cleaned will support a water film break-free when immersed in distilled water." It will be noted that this did not restrict the solvent cleaning to scrubbing only.

In an attempt to improve on solvent wiping to clean laboratory steel test panels, we use in our laboratories what we call the solvent spray cleaning method. This method is simple, fast, and economical. It requires no special apparatus beyond a regular spray gun, and the solvents used are readily available in the average paint or varnish laboratory. A large number of panels can be brought to a state of uniform and satisfactory cleanliness where they will support a film of water break-free. Fresh solvent is all that is used at the point of cleaning, and the advantages of mechanical action or jet cleaning are inherent in this method.

The panels are used as they are taken from the stock bundles with no preliminary removal of the mill oil coating. A sample immersion in distilled water will serve to check whether sufficient hydrophilic surface-active agents are present to support a film of water break-free, in spite of the presence of oily contaminants. If so, the water-soluble agents are removed by running water over the panels until they will not support a break-free film of water.

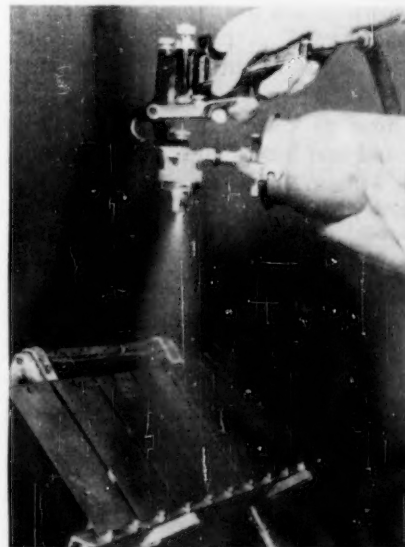


Fig. 12.—Method of Solvent Spray Cleaning.

This will assist in establishing the validity of the final water film test.

Figure 12 illustrates the proper method of solvent spray cleaning. The test panels with their shop coat of oil and incidental soil are mounted on a spray rack as shown. The nature of some rust inhibitive oils used on stock panels indicated that the degreasing solvent should be a mixture of aliphatic and aromatic types. We usually use a mixture of half V. M. and P. naphtha and half xylene, but we have found the blend of three parts of naphtha and one of cellosolve about equally efficient. There probably are others equally good.

The solvent mixture is sprayed from a conventional spray gun operated with the fluid tip wide open, but with the atomizing jets stopped down almost completely. This concentrates the spray in a much smaller area than is ordinarily used in painting.

An important factor in the method is the angle at which the spray is directed onto the panels. It should be projected from above at an acute angle to the panel (25 deg. or less) so that the washings are rinsed off ahead of the spray and not forced around to the other face of the panel. If the solvent spray strikes too nearly perpendicularly to the face of the panel, the washings are forced around the edges onto the other side of the panel. The spray is swept back and forth several times across the panels, starting at the top and working down as the soil is washed ahead of the spray. A pan is placed below the panels to catch the washings.

The technique used is exactly the same as one employs in cleaning sand and leaves off a sidewalk using a stream of water from a garden hose. The oil and dirt are driven off the panels with a coarse spray of solvent, so that only clean solvent strikes at the point of cleaning or over the area already washed.

The backs of the panels are usually degreased first, then the face sides, after which they are allowed to dry. After the panels have been cleaned, the usual precautions should be taken to avoid contaminating the panel faces in handling. When they are dry they are polished by rubbing briskly with a clean, dry

TABLE V.—PANEL PREPARATION, WATER-BREAK TESTS, AND ACTIVITY RATING AVERAGES.

| Panel Preparation   | Water-Break Test, per cent |             | Modified Mears Activity Tests, sec. |                 |                  |  |
|---|----------------------------|-------------|-------------------------------------|-----------------|------------------|--|
|   | Initial                    | Final       | Average Maximum                     | Average Minimum | Over-all Average | Difference—Average Maximum and Minimum |
| Solvent wipe V. M. and P. naphtha + cellosolve.....           | 12 and 19                  | 82 and 78   | 36                                  | 15              | 24.5             | 21                                     |
| Solvent wipe and bake V. M. and P. naphtha + cellosolve.....  | 34 and 30                  | 39 and 54   | 29                                  | 10              | 20.7             | 19                                     |
| Solvent wipe V. M. and P. naphtha + xylene.....               | 47 and 68                  | 82 and 83   | 35                                  | 11              | 23.5             | 24                                     |
| Solvent wipe and bake V. M. and P. naphtha + xylene.....      | 45 and 60                  | 80 and 86   | 28                                  | 12              | 19.4             | 16                                     |
| Solvent spray V. M. and P. naphtha + cellosolve.....          | 99 and 98                  | 99 and 97   | 21                                  | 12              | 15.5             | 9                                      |
| Solvent spray and bake V. M. and P. naphtha + cellosolve..... | 100 and 98                 | 98 and 98   | 27                                  | 12              | 18.2             | 15                                     |
| Solvent spray V. M. and P. naphtha + xylene.....              | 100 and 99                 | 98 and 98   | 18                                  | 10              | 13.6             | 8                                      |
| Solvent spray and bake V. M. and P. naphtha + xylene.....     | 100 and 100                | 82 and 82   | 29                                  | 16              | 23.0             | 13                                     |
| T. C. E. degrease.....  | 100 and 100                | 100 and 100 | 48                                  | 17              | 26.4             | 31                                     |
| T. C. E. degrease and bake.....                               | 100 and 100                | 98 and 100  | 39                                  | 14              | 23.9             | 25                                     |

cloth. This last operation removes the finely divided dirt which was originally bound to the panel by the oily film, and furthermore seems to be a necessary step in conditioning the now oil-free surface so that it will support a film of water break-free. The beneficial effects of polishing are apparent with almost any method of cleaning.

For routine laboratory tests, which may involve a relatively large number of panels in a given set, the normal practice is simply to allow the solvent spray cleaned and polished panel to air dry briefly and then proceed with the application of the test paints. However, for precise testing, the method would require the testing of each panel by immersing it in distilled water to determine whether it will support a film of water break-free. The panels should then be immersed in alcohol for 10 min., followed by air drying or force drying at 125 to 150 F. for 10 min.

The 10-min. immersion in alcohol is beneficial where there have been any deficiencies in cleaning up to that point. Where panels were solvent cleaned by wiping, the portions of the panel surfaces which would support a film of water break-free rose from an average of approximately 15 per cent to 80 per cent in one instance, from 45 per cent to 85 per cent in another.

When the panels are force dried for 10 min. at 150 F., in some in-

stances there is a drop in the water-break rating, which may be due to deep-seated contaminant which has not been entirely eliminated in cleaning. Trichlorethylene vapor degreasing is thorough, so the effects of either alcohol immersion or force drying are not very noticeable. The same is true to almost the same extent in solvent spray cleaning. Where cleaning is less efficient as in the case of solvent wiping, the effects may be more pronounced.

The comparisons are interesting when viewed side by side.

The first column of Table V gives the method of cleaning and the solvents used. The next two columns give the percentage of the surface area for the two faces of each panel which would support a film of water break-free; first, after cleaning to the point where the water-break test is called for in the specification, and, second, after the 10-min. immersion in alcohol and air drying or force drying as indicated. All the figures are averages taken from six panels in each group.

The next four columns present the results of a modified Mears activity test, using a 2 per cent  $H_2O_2$  + 0.006 per cent NaCl solution, twelve spot tests on one face of each panel. Thus the "over-all average" represents the average of 72 spot tests for each method.

It will be noted that ratings on the water-break test are rather low



and vary rather widely using solvent wiping. The blend of V. M. and P. naphtha plus xylene is somewhat more efficient than V. M. and P. naphtha plus cellosolve. The 10-min. soak in alcohol brings up the water-break rating of both, but the drop on force drying is greater with the blend using cellosolve than that using xylene.

Solvent spray cleaning and trichlorethylene vapor degreasing get high ratings on the water-break test. In this instance the blend using xylene shows a greater drop on force drying than with the cellosolve blend. It may be worth noting that while the trichlorethylene degreased panels show no loss in water-break rating after force drying, this force drying was done at 150 F. whereas trichlorethylene boils at about 190 F. In effect the trichlorethylene panels already have been subjected to higher temperatures before the original water-break test than they encounter later.

Turning to the activity tests, the solvent wiped panels show rather wide differences between the average maximum and minimum activity ratings. The solvent spray cleaned panels show the highest degree of activity and the best uniformity of activity. It is the only one to show a decrease in activity after force drying, whereas the others rather surprisingly show an increase in activity on baking even though the water-break rating dropped. In spite of the high water-break rating of the trichlorethylene vapor degreased panels, they show a relatively lower degree of activity and the widest differences in activity.

Summing up, it appears that the solvent spray cleaning method shows considerable promise as a reasonably rapid and economical method of preparing panels for laboratory test. We should remind ourselves of our original premise, which was that to prepare a group of panels satisfactorily for laboratory test purposes, each panel must be uniformly clean, uniformly active over its entire surface, and the whole group must be uniform panel to panel. In this way we may be sure that any differences observed in the performance of the coatings on test do not arise from differences in the substrate.

Solvent spray cleaning has come sufficiently close to this ideal to warrant further consideration.

**Mr. I. C. Clare<sup>13</sup> (prepared discussion)**

At the Hercules Powder Co. Experiment Station, we have arrived at a series of routine procedures for preparation of panels. These procedures will not necessarily fit the needs of other investigators but they are suited to our requirements from the standpoint both of consistency of results obtained and the rapidity with which tests may be made.

Our work at Hercules on protective coatings may be divided into two major categories: first, the evaluation of oleoresinous finishes, both clear and pigmented, which dry by oxidation and polymerization; and, second, the evaluation of lacquer and lacquer enamel coatings which dry primarily by evaporation of solvent. Our objective in the first case is to determine the performance characteristics of resinous compositions for the purpose of resin development and customer information. In the second, we wish to determine the effect of various commercially obtainable resins and plasticizers on both established and experimental film-forming materials. Naturally, the two objectives frequently overlap. To obtain this information we have established a number of routine tests which involve both free and applied films. In so far as is possible, A.S.T.M. procedures are used when available. In some cases, however, deviations from such procedures are found necessary.

In our routine tests, the general appearance of the applied film, particularly gloss, flow out, depth, and fullness are determined. Drying rate, resistance to water, alkali, impact, abrasion, and discoloration when exposed to baking conditions, and ultraviolet light, effect of gas combustion fumes, flexibility, water spotting, sweat box or tropical test performance, cold-check, and general exterior durability of the applied films are studied. For a number of these determinations, glass, wood, and tin plate panels are em-

ployed. For other tests, however, it is necessary to use steel panels and it is with the preparation of these steel panels for use in such tests that we are now concerned.

In the testing of oleoresinous coatings, steel panels are used in determining flexibility, adhesion, impact, abrasion resistance, and durability. Primed steel panels are used for obtaining discoloration data on white and pastel shades of enamels. Steel panels are also used in determination of alkali, acid, and salt spray resistance, although occasionally the alkali tests are made on glass using the common test-tube procedure. In the evaluation of lacquer coatings, steel panels are used in testing sanding properties, print and corrosive reagent resistance, sweat box or tropical test performance, and durability. Occasionally, steel panels are used in determining cold-check resistance although with furniture lacquers more commonly birch, mahogany, or walnut plywood panels are employed for this purpose.

Our steel panels are purchased in 2½ by 5½ and 6 by 12-in. sizes. They consist of oiled soft cold-rolled steel. A number of methods have been evaluated for the preparation of these panels for coating. This has varied from solvent cleaning to sand blasting. One objection to the use of solvent cleaning is that the panels frequently are slightly rusted and sometimes have a somewhat rough surface which is developed during the rolling operation. They also have sharp edges caused by the method of cutting the panels.

The procedure currently used is a result of a number of experimental efforts and for our purposes it appears to be quite satisfactory. The rough edges of the panels are smoothed off by filing. The panels are then cleaned in toluene or, if this solvent is not available, xylene. One face of the panel is then sanded until smooth, using a portable belt sander equipped with a No. 120 sanding belt, the original surface being entirely removed during the sanding operation. Sometimes, but not always, the sanded panel is polished with either 360 or 400 Wet-or-Dry Tri-Mite paper. This second operation is desirable but not essential and is done when time

<sup>13</sup> Hercules Experiment Station, Hercules Powder Co., Wilmington, Del.

permits. During the entire sanding operation, the operator has been instructed to refrain carefully from touching the surface of the panels with his hands or fingertips. This may be avoided either by the use of gloves or by very careful handling. The panels are stored in toluene if they are not to be coated immediately.

It is recognized that the sanding operation accentuates the tendency of the steel to corrode under the film, particularly when subjected to tropical or exposure tests. However, we are primarily interested in the comparative performance of the coatings in a series. In a series of this sort, one variable has been changed systematically, and standard formulations of well-known performance characteristics are included for reference. Since each series contains these comparison standards, we are able to give the panel a phosphate or similar chemical treatment to passivate the panel surface in test where corrosion of the metal may cause complications.

By subjecting each coating system to identical tests, we believe that the effect of systematic variation of the ingredients under test are adequately brought out. Naturally, the panel surface cannot be treated when the panel is subsequently to be subjected to mandrel or other flexibility tests, but surface treatment is frequently used where we are interested in tropical or sweat-box performance and exterior durability.

Rust-preventative measures are always taken when the coating is formulated for an application where such measures are common commercial practice. Examples of this are automotive and refrigerator finishes. Naturally, if the coating is designed to have an inhibitive effect on corrosion, this chemical treatment of the panel surface cannot be carried out. In a case of this sort, we consider the sanded panels to give a more severe test.

We do not consider the water-break test a suitable standard for indicating the uniformity of this sanding operation but have no suggestion for a more adequate method. A panel treated with a known amount of soil will show a water break when submitted to this test.

If the soil is removed with suitable solvent, the panel will then pass a water-break test, particularly if subjected to a mild sanding operation directly after cleaning. However, if the panel is sanded thoroughly and then polished so that the surface presented is as clean as we know how to make it, we find that the surface wets very poorly with water and a pronounced break is observed.

A study of the degree of cleanness of such sanded and polished surfaces has been made by means of copper electroplating tests. For these electroplating tests, a rather simple apparatus was set up. The following materials are required:

- 1.5-, 2- or 6-v. battery with necessary clips and wires.
- Steel panels, 25 by 50 mm.
- 150-ml. beakers.
- Copper anode 25 by 50 mm.
- 100-ohm resistance coil.
- Rochelle salts.
- Copper sulfate.

Using one cell of an ordinary 6-v. battery, the copper anode is attached to the positive pole. The panel under test constitutes the cathode and is connected to the negative pole through a 100-ohm resistance coil. The cathode and anode are suspended in the plating bath contained in a 150-ml. beaker by means of alligator clips supported by burette clamps attached to separate ring stands. The circuit is opened and closed by simply raising or lowering the cathode into the plating bath. With a distance of 45 mm. between anode and cathode, the current drawn was approximately 0.070 amp. (current density 0.0056 amp. per sq. cm.).

Two solutions were used in the preparation of the copper plating bath. The first contained 3 g. of hydrated copper sulfate dissolved in 50 ml. of distilled water. The second contained 6 g. of Rochelle salts in 50 ml. of water. When dissolved, the two solutions were mixed and diluted to 125 ml.

Referring again to the soiled, partially cleaned, and thoroughly cleaned panels, this last being polished after real dressing down of the surface with abrasive, we find that if the first two panels are subjected to a copper plating operation using the described equipment, the soiled and partially cleaned panels show

either no deposition or an irregular deposition of copper on the panel surface. The carefully sanded panel, however, plates smoothly and evenly, indicating, in our opinion, the thoroughness of the cleaning operation.

The water-break test has been used on a number of panels cleaned with different solvents and subjected to various degrees of sanding. It does not appear to give an adequate story since the more thorough the cleaning operation the more tendency there is for a water break to be observed. This water break is also observed on the soiled or unclean panels but those which are intermediate in cleanliness as determined by our electroplating tests do not show the water break. Harris<sup>14</sup> has discussed the effect of anionic and cationic agents when adsorbed on metal surfaces. We believe that the wetting effect is obtained when a hydrophilic film is present on the metal surface. When this is removed entirely, the water break is no longer observed.

We do not recommend the electroplating method as a means of determining the suitability of steel panels for use in protective coating evaluations, although some systematic scheme for determining the efficiency of the cleaning operation might be developed by the use of this electroplating technique. This procedure was developed in our laboratories by B. S. Van Zile for the purpose of observing the efficiency of metal cleaning compositions and, at a later date, will be described in more detail by Van Zile pursuing the original objective.

We hope that this discussion will not serve to confuse the problem and are presenting it for what it may be worth to assist in consideration and development of an adequate specification.

**Mr. H. A. Nelson<sup>15</sup> (prepared discussion)**

It should be kept in mind that in so far as Tentative Method D 609 is concerned, the A.S.T.M. is primarily interested in preparing panels of limited size, which are to be used for laboratory tests of the acceler-

<sup>14</sup> J. C. Harris, "Metal Cleaning: II—Soil Removal Performance Methods," *ASTM BULLETIN*, No. 136, August, 1945, p. 31.

<sup>15</sup> Technical Department, The New Jersey Zinc Company (of Pa.), Palmerton, Pa.



ated type; that is, immersion, humidity, salt spray, light and water exposure, etc. Therefore this method must go beyond the requirements of average commercial surface preparation procedures in an effort to reduce the number of variables in these tests. We should, if possible, know what the cleaning procedure does to the uniformity of the surface of the steel panel, which should be as uniform as the uniformity of the steel itself will permit and no less. For this reason we are interested in tests to show that the cleaning procedure has really cleaned the surface and not added to the nonuniformity by leaving localized contamination or areas that are less subject to corrosion due to some reaction with the chemicals that are used. We should also like to know something about the general activity of the surface (or its tendency to corrode), but this is really secondary to uniformity and, of course, to reproducibility of the results obtained by the cleaning procedure.

When a panel passes the water-break test, we have, it is true, assumed that it indicates that the surface is as uniform as the characteristics of the steel permit. The fact that a break-free film of water may only indicate that hydrophobic matter is absent is disturbing, but it is the test with which we have had most experience so it cannot be discarded in an offhand manner. However, there has been some debate as to the place of the water-break test in the specification method. Some consider it a periodic check on the efficacy of the cleaning procedure, to be used only on occasional panels. Others think that it should be the final step on every panel, with the idea that contact with water has a stabilizing effect on the surface. Still others prefer an alcohol dip for stabilizing and drying the surface and, as Mr. Van Loo points out, there is evidence in favor of this.

A test for exploring the effectiveness of cleaning procedures, as to producing uniformity and activity, is badly needed. The copper plating test suggested by Mr. Clare should be studied. Another test, already mentioned by Messrs. Elm, Singleton, and Van Loo and which undoubtedly has possibilities, is the spot corrosion test with dilute hy-

drogen peroxide solution. This was suggested by Mr. Reinhard of our laboratory as a simplification of the test used by Mears and Evans<sup>16</sup> in their study of the probability of corrosion on steel surfaces.

There is increasing evidence that by the application of statistical methods this simplified test can supply information about the degree of activity of the surface (tendency to rust) as well as the uniformity of this tendency, and that it should be useful for rating cleaning procedures. Experiments in our laboratory indicate that cleaning procedures may vary to a considerable degree in the time (seconds) required to produce first visible evidence of corrosion under a drop of hydrogen peroxide solution. Examples of such experimental results are shown in Table VI.

The solution used consists of 16 ml. of Superoxol (30 per cent  $H_2O_2$ ) in 984 ml. of distilled water. Drops (one or two) from an ordinary medicine dropper are uniformly distributed in groups of four spots across and four uniformly spaced rows extending to the bottom of the panel. Each row of four spots is timed as a unit and, in order to average the starting time, the stop watch can be started after the second spots. This is permissible since readings are recorded only to the nearest 5 sec. The observer watches for the first indication of brown color in any of the small bubbles which form on the steel surface under the spot. The lighting should be adjusted to avoid reflections of the light source; fluorescent lighting can be used to advantage. Hydrogen peroxide solutions are sensitive and at times erratic and should

be checked against standard panels periodically prepared and kept in a desiccator. (Some make the solution more active by adding NaCl, but the value of this is questioned.) Panels cleaned by the third procedure in Table VI are surprisingly reproducible and have been used as standards for checking the activity of the solution. This cleaning procedure may also prove to be useful as a relative standard for comparing the effectiveness of other cleaning procedures.

The results with the first procedure are interesting because of the indication that an inhibiting rinse may not react uniformly on steel surfaces unless the procedure is more carefully controlled than it was in this case. So far, the results do not justify any conclusions as to possible relationships between surface uniformity indicated by a break-free water film and uniformity of readings obtained by the spot test.

#### Mr. R. I. Wray<sup>17</sup> (prepared discussion)

The paper by Mr. Elm presents a very interesting discussion of an important subject. The need for accelerated tests to evaluate paint coatings is indeed great since many of the coatings now available do not have as much background upon which to evaluate them as some of the older types of coatings. Mr. Elm's analysis of the problem is very good and the various steps of procedure he proposes appear quite logical.

In preparing panels for painting, the necessity for eliminating sharp edges and corners which might cause rapid failure of the paint cannot be

<sup>16</sup> R. B. Mears and U. R. Evans, "The Probability of Corrosion," *Transactions, Faraday Soc.*, Vol. 31, Part 1, p. 527 (1935).

<sup>17</sup> Aluminum Company of America, New Kensington, Pa.

TABLE VI.—EXPERIMENTAL RESULTS.

|  | Surface Uniformity    |                      |                               |                              | General Surface Activity, Mean of All Readings, sec. |
|--|-----------------------|----------------------|-------------------------------|------------------------------|--|
|  | Highest Reading, sec. | Lowest Reading, sec. | Mean of Higher Readings, sec. | Mean of Lower Readings, sec. |  |
| Procedure which includes a rinse in a reactive inhibiting agent (3 panels <sup>a</sup> with 16 spots on each panel)..... | 735 + <sup>b</sup>    | 95                   | 350                           | 160                          | 220 <sup>c</sup>                                     |
| Solvent cleaning procedure (4 panels <sup>a</sup> —16 spots).....  | 125                   | 20                   | 100                           | 55                           | 75   |
| Electrolytic cleaning as used in metal plating operations (4 panels <sup>a</sup> —16 spots).....                         | 35                    | 15                   | 30                            | 20                           | 25   |

<sup>a</sup> Panels about 3½ by 6 in. and of steel meeting the requirements of Tentative Method D 609.

<sup>b</sup> Next highest readings were 480+ on the second panel and 360 on the third panel.

<sup>c</sup> A high reading indicates low order of surface activity.

overemphasized. Their effect can be minimized by carefully rounding all edges and corners by filing. The use of fairly heavy gage metal (No. 14 to 16 gage) for the panels aids in permitting better rounding of the edges. The use of additional paint or wax coatings on the edges still further improves this condition, but it is difficult to paint a *sharp* edge satisfactorily.

In the application of the coating, the use of automatic spraying or dip-coating at a slow uniform rate will assure a more uniform paint film over the entire panel. This, however, does not eliminate the desirability of making accurate film thickness measurements.

The effect of scratches in the paint film is very important, as pointed out by Mr. Elm. If the paint films are to be deliberately scratched, the scratches should be small and uniform. Care should be taken that the scratches do not deeply score the metal surface itself. The practice of scratching paint films on metal panels is open to question for a number of reasons. This is particularly true if the metal has been given a special treatment, such as bonderizing, prior to painting, since the scratch will disrupt the protective film on the metal itself. As pointed out by Mr. Elm, it is important that differences in rusting be caused by differences in the protective coatings and not by differences in the corrosivity of the metal.

Our observations are in agreement with Mr. Elm's statement that more paint blistering occurs with the same paint system in fresh water than in salt water. His explanation appears to be a logical one. Blistering of the paint itself should not be confused with corrosion blistering as Elm points out. Results have been observed on aluminum panels similar to those on steel described by Elm.

In discussing the relative merits of testing by complete immersion in water and testing by exposure to high humidity, Mr. Elm reaches the conclusion that there is no difference in the amount of water absorbed by identical paint films exposed to the two environments. Several years ago we conducted a few tests on free paint films (not attached to any substrate). The paint film used in

these tests consisted of one coat of aluminum paint made with a long oil varnish vehicle. It was found that different amounts of water were absorbed when the paint film was immersed in distilled water maintained at 80 F. and when exposed to 100 per cent humidity at 80 F. In a 24-hr. period the film which was exposed to 100 per cent humidity showed a gain of 17.4 mg. of moisture per gram of film while the film which was immersed in distilled water absorbed only 14.7 mg. of moisture per gram of film. The moisture permeability of the paint film was also found to be greater when exposed to high humidity than when exposed to liquid water.<sup>18</sup> Whether these relationships would hold when the paint films were attached to a metal substrate was not determined.

The interpretation of the results of accelerated tests in terms of the service life of the paint coating is perhaps the most important phase of the problem. It should be pointed out that immersion tests or humidity tests have the most significance when evaluating paint coatings for service conditions involving exposure to moisture. The effect of aging of the paint on its embrittlement is not taken into account in an accelerated test. It might easily be possible to have a paint which would give exceptionally good results in an accelerated test of short duration and yet give inadequate protection to a metal surface for long periods because of the rapid embrittlement of the film with age. Short oil varnish base enamels sometimes behave in this manner. It would, therefore, be necessary to establish a correlation between accelerated and service tests for each and every type of coating. Before starting an accelerated test the exact nature of the coating must be known. It might, thus, be difficult to evaluate any new type of coating on which no service experience existed. For most coatings, however, the statistical method of evaluation proposed by Elm should give the desired information and as he points out it should prove well worth the trouble in carrying it out.

<sup>18</sup> Junius Edwards and R. I. Wray, "Permeability of Paint Films to Moisture," *Industrial and Engineering Chemistry*, Vol. 28, pp. 549-559 (1936).

Messrs. W. H. Lutz<sup>19</sup> and E. J. Lewis<sup>19</sup> (*prepared discussion*)

Mr. Elm's discussion is complete and logical. We feel that he has performed a service in focusing attention on fundamentals rather than on controversial details.

We are in accord with Mr. Elm's remarks on the importance of panel uniformity, surface preparation and activation in all tests involving metal panels. We also share his views relative to small test panels. We have standardized on 6 by 12-in. panels in order to reduce edge and corner areas to a small proportion of the testing area. Because of our own difficulties with small panels, we are frequently surprised to note that most test panels offered by suppliers are of relatively small size. Mr. Elm's evaluation of the water-break test for panel cleanliness agrees with ours.

Our experience with molten wax for protecting panel edges has often been disappointing. When molten, the wax tends to creep up the panel face; when cool, it becomes brittle and breaks away unless handled very gently. We prefer to use several coats of spar varnish, when time permits.

We agree with Mr. Elm that protection from corrosion depends on film continuity and that minute pinholes and imperfections exert a tremendous influence on failure. We have found the salt-spray test distinctly useful in showing up film irregularities and we do not entirely share Mr. Elm's skepticism of this test. In our opinion, it reproduces the failures encountered under actual conditions of corrosion more closely than do water-immersion tests. In the salt-spray test, the metal corrodes but the paint film does not usually blister. If blistering does occur, it is purely a secondary effect. In immersion testing, blistering seems to be the predominant form of film failure.

Mr. Elm expresses surprise at the lack of agreement among experienced paint testing engineers. Experts always seem to disagree—whether they be paint test engineers, surgeons, or lawyers. Disagreement is a healthy sign for it indicates that people are thinking. Most disagreement stems from honest differences

<sup>19</sup> Pratt & Lambert, Inc., Buffalo, N. Y.



of opinion. Opinions differ because there is insufficient factual evidence to support one sweeping conclusion. We need more facts in order to eliminate some of the controversial opinions.

One reason for disagreement is that each expert studies his own favored formulas and draws conclusions from these formulas. Rarely does he test exactly the same paint that someone else is testing. As a result there is no bridge between his results and the results of other laboratories or other tests. Our laboratory has made a practice of always exposing the same basic test paint in every series of house paint exposure tests that it has made in the last fifteen years. The results in any one series can be interpreted in terms of other series through this common denominator. However, we cannot interpret our results in terms of tests made by other laboratories.

Has Committee D-1 ever considered the possibilities of setting up a short series of standard reference paints which would be available in liquid form to all laboratories for exposure, immersion, and physical testing purposes? By including one or more of these reference standards in every industrial test, it would not take long to build up an enormous amount of information about these paints. Beyond that, every test in which the paints had been included could be compared with other tests containing the paints. We feel that this proposal would help to clear up some of the disagreement that exists today.

Mr. Elm's proposal to undertake a statistical study in order to predetermine durability is scientifically sound and certainly worthy of trial, but few companies or laboratories would have the personnel, time or testing facilities to undertake such a study. The industry needs simple testing procedures.

#### Mr. A. C. Elm (*author's closure*)

Mr. Wirshing suggests that it is practically impossible "to check each panel in a manner so as to be able to guarantee that each spot on the panel is the same as every other spot on the panel." I believe that a degree of uniformity can be achieved which will be fully adequate for most paint testing purposes by fol-

lowing a scheme similar to the one outlined in my paper. However, if Mr. Wirshing should be proved to be correct then there is only one way open to the paint test engineer—namely, to follow the principles laid down by Mr. Cranmer and to subject a sufficient number of panels to simultaneous testing so as to obtain an adequate basis for a statistical evaluation. The inclusion of a standard alone, no matter how well established and how extended the experiences gained with it, is entirely insufficient to guarantee the reliability of the test results. One standard does not eliminate errors due to nonuniformity of the substrate surfaces, although it may serve as a check on the exposure conditions.

Mr. Wirshing states that the influence of inadequately coated areas such as panel edges upon the behavior of the paint system under test is of considerable interest to the automotive engineer and that for this reason they prefer not to give the edges of their test panels additional protection. This method of testing does not guarantee that all edges are left inadequately protected to the same degree, and therefore leaves considerable doubt whether a certain effect observed is the result of edge failure or of an intrinsically poor paint system. To get the full value of such tests, it would be preferable to eliminate this element of uncertainty and to scratch the test area in a carefully standardized manner.

One of the comments made by Mr. Clare is of particular interest. He stated that a thoroughly sanded and polished steel panel presenting the ultimate in clean steel surfaces wets very poorly with water and gives a pronounced break. This observation illustrates rather strikingly one of the points that I tried to make in my paper, namely, that the water-break test does not furnish any information on the cleanliness of the substrate surface but merely indicates whether it is uniformly hydrophilic in nature. Surface chemical experiments conducted in our own laboratories have shown that a thoroughly clean steel surface is organophilic but becomes increasingly hydrophilic as rusting proceeds.

It is very difficult to fit the results of the water absorption experiment reported by Mr. Wray into the picture which we derived from our own experiments. However, without knowing the exact experimental details of Mr. Wray's experiment, I should like to attempt an explanation. It would be my guess that water-soluble material of some sort was leached from the film specimen immersed in the distilled water and depressed its vapor pressure sufficiently to cause the slightly lower water absorption as compared with the absorption from the vapor.

The bad experiences Messrs. Lutz and Lewis report with waxed edges are probably due to an excessively high temperature of the molten wax used for coating the panel edges. When the wax is kept only a few degrees above its melting point and the panel is slightly below this temperature when it is dipped into the wax, creepage of the wax is kept at a minimum. Embrittlement of the wax edges at lower than room temperatures, though rather serious with some waxes, gives no trouble when a good grade of ceresin wax is used. For tests at very low temperatures the scheme of coating the panel edges with extra coats of paint is preferable.

Mr. Singleton's observations regarding the effect of sanding on the corrosion tendency of steel surfaces as measured by a modified Mears test would be of greater value if he also reported the time elapsed between sanding and testing and the conditions of storage during this interval. It would then be possible to form some idea of the density and nature of the oxide film that very likely formed on the panel surface. In our experiments we have endeavored to avoid such secondary effects as that reported by Mr. Singleton because they tend to becloud the issue. We prefer to hold the panel on a magnetic chuck during the sanding operation since the massive chuck aids considerably in dissipating the heat generated. Mr. Singleton's report illustrates strikingly one of the many variables that can be introduced and should be eliminated or gotten under control if interpretable results are to be guaranteed.

# Effect of Alkalies in Portland Cement on the Durability of Concrete<sup>1</sup>

Reported by Committee C-1 on Cement, through its Working Committee on Effect of Alkalies in Portland Cement on the Durability of Concrete

R. F. Blanks,<sup>2</sup> Chairman

Louis Anderson  
G. A. Beckett  
W. C. Hanna

T. E. Stanton  
Bailey Tremper  
C. E. Wuerpel

Since 1940 there have appeared in the literature several articles discussing the possibility of reaction between "alkali," set free in the hydration of cement, and certain minerals occurring in concrete aggregate. This action has been suggested as responsible for many cases of concrete deterioration, manifesting itself in expanding concrete and "map cracking" of the surface. Many investigators have connected this type of concrete failure to the use of cement containing  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  in amounts considerably greater than ordinarily found, coupled with reactive aggregates which have been found to produce expansion when combined with such cement. Expansions, duplicating those experienced in structures, have been produced in the laboratory under particular conditions of exposure.

As a result of the agitation on this subject, there was formed in 1941 within Committee C-1 on Cement, a subcommittee to investigate and consider this question.

SINCE its organization this sub-committee has been active by way of a voluminous exchange of correspondence among its members. It is believed that the subcommittee members are in possession of most all of the information that has accumulated on the subject of the effect of alkalies in portland cement, which information is also available to the membership of Committee C-1 through articles published in the technical and professional journals as well as A.S.T.M. *Proceedings*. A complete bibliography is to be found in the appendix to the 1943 Report of Committee C-1.<sup>3</sup> At the end of this report, a list of later articles on the subject brings the bibliography up to date. The subcommittee's activities have, in the main, found expression in those articles published individually by its members. However, in the last assembled meeting of the subcommittee, it was decided to present individual views on the subject in written form which also have been printed in the appendix to Committee C-1 report for 1943.<sup>3</sup>

The generally accepted method of

most laboratories for studying the reaction between aggregate and cement has been the mortar bar expansion test incorporating the active aggregate in combination with cements of various alkali contents, from high to low. The committee has found that many peculiar, anomalous and sometimes conflicting results have been secured with this test. It was, therefore, agreed that a cooperative test program should be undertaken to determine the dependability of the mortar bar expansion test and the degree to which the data from it can be reproduced. Such a program was begun early in 1944 with most of the members, as well as the Portland Cement Association, the National Bureau of Standards, and the laboratory of the New Jersey Highway Department, participating. Five aggregates (two nonreactive) and six cements having total alkali contents varying from 0.16 per cent to 1.37 per cent were distributed to ten laboratories with instructions to prepare three 1 in. by 1 in. by 10 in. mortar bars for 30 combinations using each cement with each aggregate. These were placed in sealed storage at 70 F. and expansion measurements made upon them at stipulated intervals. Details of the program and a description of the materials follow.

## Cooperating Laboratories:

1. California Division of Highways, T. E. Stanton
2. U. S. Bureau of Reclamation, R. F. Blanks
3. California Portland Cement Co., W. C. Hanna
4. Alpha Portland Cement Co., Louis Anderson
5. Washington State Dept. of Highways, Bailey Tremper
6. War Department, C. E. Wuerpel
7. National Bureau of Standards, P. H. Bates
8. Portland Cement Association, F. R. McMillan
9. Public Roads Administration, F. H. Jackson
10. New Jersey State Highway Department, F. H. Baumann

NOTE: The order is not the same as given in the tables or figures.

## Aggregates:

1. Perkins sand (nonreactive)
2. Pure limestone, crushed (nonreactive)
3. White River gravel, crushed (reactive)
4. Ninety per cent No. 1 sand plus 10 per cent crushed siliceous magnesian limestone (reactive) (combined by individual laboratories)
5. Ninety per cent No. 2 sand plus 10 per cent crushed siliceous magnesian limestone (reactive) (combined by individual laboratories)

All material passed the No. 4 sieve. The pure limestone was graded 19 per cent of each sieve size from No. 100 to No. 8 and 5 per cent passing the No. 100 sieve. The Perkins sand and the crushed White River gravel were processed to approach the same grading if practicable, to minimize variations in con-

<sup>1</sup> Authorized for publication by Committee C-1 on Cement.

<sup>2</sup> Engineering Control and Research, U. S. Bureau of Reclamation.

<sup>3</sup> *Proceedings*, Am. Soc. Testing Mats., Vol. 43, p. 195 (1943)



sistency of the mortar. When this was not feasible, gradings were to fall within reasonable ranges. The crushed siliceous magnesian limestone was graded to pass the No. 20 and be retained on the No. 80 sieves.

#### Cements:

gate mixture; each cement being combined once with each aggregate, making 30 groups. Mix of 1:2.25 by weight; water-cement ratio of 0.50 by weight, consistency variable. Mixing was done in a bowl (enamel-ware or other nonabsorbent, non-corroding material) of about 1-gal. capacity by vigorous and continuous

stirring, squeezing and kneading with one hand protected by a rubber glove. The materials, 450 g. of cement, 1012.5 g. of aggregate and 225 g. of water, sufficient for making three bars, were introduced in the following manner:

1. The water was placed in the bowl, which had just been wiped with a damp cloth.
2. The cement was added to the water and mixed for 30 sec.
3. Approximately one half of the sand was added and mixed for 30 sec.
4. Then the remainder of the sand was added and mixed for 1½ min.

Immediately following mixing, the bars were molded in one or two layers, each layer being compacted with the forefingers by pressing the mortar into the corners, around the reference points and along the surfaces of the molds until a homogeneous specimen was obtained. After the top layer had been compacted, the mortar was cut off flush with the top of the mold and the surface smoothed with a few strokes of the trowel.

#### Storage Containers and Measurements:

After the mold had been filled, it was immediately placed in the moist closet or moist room and remained there for 24 hr. At the expiration of 24 hr. the specimens were removed from the molds, measured and placed in sealed containers which were stored under a constant temperature of 70 F. and which contained free water not in contact with the specimens.

The containers, with a small amount of water in them, were of sheet metal and constructed so that they could be sealed against mois-

#### CHEMICAL ANALYSIS, PER CENT

| Series.....                                     | No. 1 <sup>a</sup> | No. 2 <sup>a</sup> | No. 3 <sup>a</sup> | No. 4 <sup>a</sup> | No. 5 <sup>a</sup> | No. 6 <sup>b</sup> |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Bureau of Reclamation                           | No. 2735           | No. 2265           | No. 2480           | No. 2473           | No. 3656           | No. 5081           |
| SiO <sub>2</sub> .....                          | 22.00              | 24.50              | 23.83              | 22.42              | 24.71              | 21.45              |
| Al <sub>2</sub> O <sub>3</sub> .....            | 4.96               | 4.50               | 3.79               | 4.64               | 4.05               | 5.70               |
| Fer <sub>2</sub> O <sub>3</sub> .....           | 3.81               | 3.25               | 3.31               | 3.69               | 3.08               | 2.61               |
| CaO.....  | 64.78              | 62.09              | 63.07              | 62.73              | 63.23              | 63.22              |
| MgO.....  | 1.30               | 1.02               | 2.62               | 2.68               | 0.97               | 2.82               |
| SO <sub>3</sub> .....                           | 1.60               | 2.40               | 1.66               | 1.83               | 1.86               | 1.79               |
| Loss.....                                       | 1.14               | 1.50               | 0.99               | 1.10               | 0.82               | 1.26               |
| Free CaO.....                                   | 0.44               | 0.86               | 0.44               | 0.43               | 0.64               | 0.70 <sup>a</sup>  |
| Na <sub>2</sub> O.....                          | 0.06               | 0.18               | 0.44               | 0.53               | 0.99               | 0.05               |
| K <sub>2</sub> O.....                           | 0.10               | 0.34               | 0.22               | 0.36               | 0.38               | 1.30               |
| Na <sub>2</sub> O + 0.658 K <sub>2</sub> O..... | 0.13               | 0.40               | 0.58               | 0.77               | 1.24               | 0.91               |
| Total alkali.....                               | 0.16               | 0.52               | 0.66               | 0.89               | 1.37               | 1.35               |
| C <sub>2</sub> S.....                           | 53.0               | 24.6               | 40.5               | 43.1               | 32.5               | 47.0               |
| C <sub>3</sub> S.....                           | 23.1               | 51.8               | 37.8               | 31.8               | 46.4               | 27.1               |
| C <sub>4</sub> A.....                           | 6.7                | 6.4                | 4.4                | 6.0                | 5.5                | 10.7               |
| C <sub>4</sub> AF.....                          | 11.6               | 9.9                | 10.1               | 11.2               | 9.4                | 7.9                |
| CaSO <sub>4</sub> .....                         | 2.7                | 4.1                | 2.8                | 3.1                | 3.2                | 3.0                |

<sup>a</sup> Determinations by A.S.T.M. Standard Methods of Chemical Analysis of Portland Cement (C 114-44) except alkalis which are determined by A.S.T.M. Tentative Methods of Chemical Analysis of Portland Cement (C 114-44 T), 1944 Book of A.S.T.M. Standards, Part II, pp. 14 and 1214, respectively.

<sup>b</sup> Analysis except free lime, reported by Mr. Louis Anderson (Alkalies determined by A.S.T.M. method C 114-42, 1942 Book of A.S.T.M. Standards, Part II, p. 14).



Tank Assembly—Alkali-Aggregate Reaction Program.  
Used for Storing 10 by 1 by 1 in. Mortar Bars.

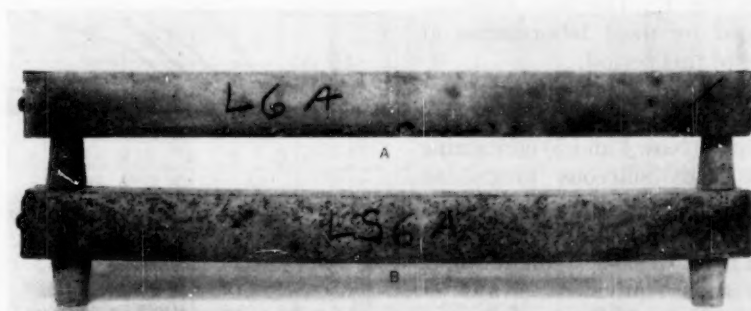
- A Perforated false bottom to support mortar bars above water in bottom of tank.  
B Grating with 1½ in. openings. Placed 9 in. above bottom of tank to maintain bars in a vertical position and to prevent bars touching each other.  
C Lid for tank. Lid sealed on tank with two layers of 1 inch masking tape.  
D Storage tank.

#### PROCEDURE

##### Proportioning, Mixing, and Molding Specimens:

Molds, gage points, and comparator were the equipment specified in A.S.T.M. Standard Method of Test for Autoclave Expansion of Portland Cement (C 151-43).<sup>4</sup> Changes in length of the test specimen were measured by a dial gage or micrometer comparator having a range of at least 0.3 in. Three specimens were made for each cement-aggre-

<sup>4</sup> 1944 Book of A.S.T.M. Standards, Part II, p. 44.



Mortar Bars—Alkali-Aggregate Reaction Program.  
After 8 Weeks in Storage Tanks.

- A Mortar Bar Made with Pure Limestone and High Alkali (K<sub>2</sub>O) Cement No. 5081. Note absence of speckled condition and warping.  
B Mortar Bar Made with 90 per cent Pure Limestone Plus 10 per cent Siliceous Magnesian Limestone and High Alkali (K<sub>2</sub>O) Cement No. 5081. Note speckled condition and warping of bar.

TABLE I.—SUMMARY OF EXPANSION OBTAINED BY ALL 10 CONTRIBUTING LABORATORIES.

| Aggregate   | Cement |                             |                            | Expansion, per cent |         |         |          |          |          |
|---|--------|-----------------------------|----------------------------|---------------------|---------|---------|----------|----------|----------|
|   |        | Na <sub>2</sub> O, per cent | K <sub>2</sub> O, per cent | 2 weeks             | 4 weeks | 8 weeks | 12 weeks | 16 weeks | 52 weeks |
| No. 1—Perkins Sand.....   | No. 1  | 0.06                        | 0.10                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.00     |
|   | No. 2  | 0.18                        | 0.34                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.01     | 0.01     |
|   | No. 3  | 0.44                        | 0.22                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.01     | 0.01     |
|   | No. 4  | 0.53                        | 0.36                       | 0.00                | 0.00    | 0.00    | 0.01     | 0.01     | 0.01     |
|   | No. 5  | 0.99                        | 0.38                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.01     | 0.01     |
|   | No. 6  | 0.05                        | 1.30                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.01     | 0.01     |
| No. 2—Pure Limestone.....   | No. 1  | 0.06                        | 0.10                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.00     |
|   | No. 2  | 0.18                        | 0.34                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.01     |
|   | No. 3  | 0.44                        | 0.22                       | 0.00                | 0.00    | 0.00    | 0.01     | 0.01     | 0.01     |
|   | No. 4  | 0.53                        | 0.36                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.01     | 0.01     |
|   | No. 5  | 0.99                        | 0.38                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.01     | 0.01     |
|   | No. 6  | 0.05                        | 1.30                       | 0.00                | 0.00    | 0.00    | 0.01     | 0.01     | 0.01     |
| No. 3—White River Gravel.....   | No. 1  | 0.06                        | 0.10                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.00     |
|   | No. 2  | 0.18                        | 0.34                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.01     | 0.01     |
|   | No. 3  | 0.44                        | 0.22                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.01     | 0.03     |
|   | No. 4  | 0.53                        | 0.36                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.01     | 0.08     |
|   | No. 5  | 0.99                        | 0.38                       | 0.00                | 0.00    | 0.01    | 0.02     | 0.03     | 0.19     |
|   | No. 6  | 0.05                        | 1.30                       | 0.00                | 0.00    | 0.01    | 0.02     | 0.03     | 0.20     |
| No. 4—Perkins Sand + 10 per cent siliceous magnesium limestone.....   | No. 1  | 0.06                        | 0.10                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.00     |
|   | No. 2  | 0.18                        | 0.34                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.01     |
|   | No. 3  | 0.44                        | 0.22                       | 0.00                | 0.00    | 0.01    | 0.01     | 0.02     | 0.23     |
|   | No. 4  | 0.53                        | 0.36                       | 0.00                | 0.00    | 0.02    | 0.10     | 0.20     | 0.72     |
|   | No. 5  | 0.99                        | 0.38                       | 0.01                | 0.14    | 0.35    | 0.45     | 0.52     | 0.65     |
|   | No. 6  | 0.05                        | 1.30                       | 0.02                | 0.13    | 0.38    | 0.52     | 0.64     | 0.90     |
| No. 5—Pure Limestone + 10 per cent siliceous magnesium limestone..... | No. 1  | 0.06                        | 0.10                       | 0.00                | 0.00    | 0.00    | 0.00     | 0.00     | 0.00     |
|   | No. 2  | 0.18                        | 0.34                       | 0.00                | 0.00    | 0.00    | 0.01     | 0.01     | 0.01     |
|   | No. 3  | 0.44                        | 0.22                       | 0.00                | 0.01    | 0.02    | 0.06     | 0.10     | 0.41     |
|   | No. 4  | 0.53                        | 0.36                       | 0.00                | 0.06    | 0.27    | 0.33     | 0.44     | 0.86     |
|   | No. 5  | 0.99                        | 0.38                       | 0.08                | 0.25    | 0.42    | 0.50     | 0.54     | 0.59     |
|   | No. 6  | 0.05                        | 1.30                       | 0.27                | 0.43    | 0.60    | 0.69     | 0.75     | 0.82     |

ture loss, with provisions for supporting the bars vertically with the lower end of the bar (including the insert) entirely above the water and with spacers to avoid contact between specimens. Separate containers were used for each cement, and were large enough to give space for 15 specimens.

Measurements were made at weekly intervals for four weeks and at four-week intervals thereafter. The specimens were reversed end for end and the water changed at each reading.

#### DISCUSSION OF RESULTS

The average of the expansion found by ten laboratories for the 30 combinations of cement and aggregate at various ages to 52 weeks are listed in Table I and shown graphically in Fig. 1. The tests were discontinued by most laboratories at the end of this period.

As anticipated, test bars combining the high alkali cements with aggregates (Nos. 4 and 5) containing 10 per cent siliceous magnesium limestone showed the earliest and greatest expansion and continued to expand to 52 weeks. Cement No. 3, with a soda equivalent (Na<sub>2</sub>O + 0.658 K<sub>2</sub>O) of 0.58 per cent showed no significant expansion with any aggregate at eight weeks but started to expand with aggregate No. 5 at 12 weeks and produced considerable

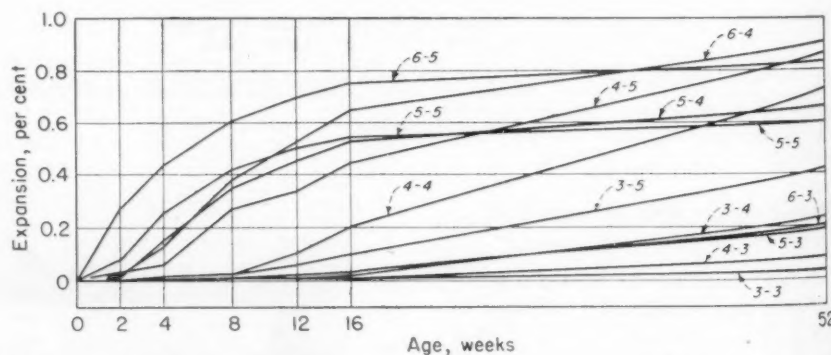
expansion with aggregates Nos. 4 and 5 at 52 weeks. The crushed White River gravel showed only a negligible expansion at 16 weeks, but, by 52 weeks, this material combined with cements Nos. 5 and 6 expanded 0.2 per cent, which value is in good agreement with results previously reported by Mr. Tremper (36).<sup>5</sup> It is readily seen from Fig. 1 that conclusions based on the relative expansion of the 30 combinations at 8 or even 12 weeks,

<sup>5</sup> The boldface numbers in parentheses refer to the references appended to this paper.

would likely be misleading. Some combinations require more time to start expanding, but even though their expansion is delayed (as in the case of cement No. 4 and aggregate No. 4) they may later expand at such a rapid rate that they will be among the most expansive groups at later ages.

A presentation to Committee C-1 of the complete expansion data on 900 individual specimens would be too voluminous and serve no useful purpose. However, in Tables II, III, and IV the average expansion obtained by each laboratory is listed, together with the range of the three values averaged and their computed coefficient of variation, for the three most active aggregates in combination with the three highest alkali cements. The coefficient of variation is a measure of the dispersion of test results and is explained on page 15 of the A.S.T.M. Manual on Presentation of Data.<sup>6</sup> It is defined as the ratio of the standard deviation of a set of numbers to their average, expressed as a percentage. In addition to the range and coefficient for the three specimens in each laboratory, values comparing laboratory-to-laboratory averages are shown for each combination and age. Data at the earlier ages were omitted for brevity and also because, in the main, they

<sup>6</sup> A.S.T.M. Manual on Presentation of Data, Am. Soc. Testing Mats., issued as separate publication.



| CEM.-Na <sub>2</sub> O-K <sub>2</sub> O | AGGREGATE                          |
|---|------------------------------------|
| 1-.06-.10                               | 1-PERKINS SAND                     |
| 2-.18-.34                               | 2-PURE LIMESTONE                   |
| 3-.44-.22                               | 3-WHITE RIVER GRAVEL               |
| 4-.53-.36                               | 4-PERKINS SAND & 10% SI. MG. LS.   |
| 5-.99-.38                               | 5-PURE LIMESTONE & 10% SI. MG. LS. |
| 6-.05-1.30                              |                                    |

#### NOTES

- (1) Numbers shown on curves indicate cement and aggregate respectively.
- (2) Cements 1 and 2 with aggregates 3, 4 and 5 and all cements with aggregates 1 and 2 showed less than .02 per cent expansion at 52 weeks and are not plotted.

Fig. 1.—Average of Expansions Found by Ten Laboratories.



were of small magnitude and for them a statistical analysis would have minor significance. In every instance, in these tables, the labora-

tory-to-laboratory values for range and coefficient of variation are considerably greater than the average of the ranges and coefficients for

groups of three specimens. In other words, the agreement between laboratories was not so good as the average-within-batch agreement. The laboratory-to-laboratory range approaches, or often exceeds, the average expansion, indicating wide variation between individual results. This is further reflected in large figures for the laboratory-to-laboratory coefficient of variation, although it is observed that these values decline with increasing magnitude of expansions. The laboratories, therefore, are in better agreement when considerable expansion is being registered than when the expansions are only moderate.

Figure 2 further illustrates the extent to which the laboratories agree on the expansions found for the three reactive aggregates. In the case of cement No. 3 and aggregate No. 5, values obtained by the ten laboratories ranged from 0.04 to 1.12 per cent. Such nonconcordant results were obtained in spite of the fact that a reasonable effort was made to secure uniformity in the procedure and in the materials distributed to the laboratories. One point of agreement, however, is quite evident in Fig. 2. No laboratory showed any significant expansion with cement

TABLE II.—STATISTICAL ANALYSIS.  
Aggregate No. 3—White River gravel.

| Cement  |              | Laboratory | Expansion at Two Ages, per cent |       |                          |           |       |                          |
|---|--------------|------------|---------------------------------|-------|--------------------------|-----------|-------|--------------------------|
|   |              |            | 16 Weeks                        |       |                          | 52 Weeks* |       |                          |
|   |              |            | Average                         | Range | Coefficient of Variation | Average   | Range | Coefficient of Variation |
| No. 4<br>(Na <sub>2</sub> O = 0.53,<br>K <sub>2</sub> O = 0.36) | No. 1        | 0.02       | 0.00                            | 0     | 0.18                     | ...       | ...   |                          |
|   | No. 2        | 0.01       | 0.00                            | 0     | 0.02                     | 0.00      | 0     |                          |
|   | No. 3        | 0.01       | 0.01                            | 47    | 0.05                     | 0.04      | 34    |                          |
|   | No. 4        | 0.01       | 0.00                            | 0     | 0.06                     | ...       | ...   |                          |
|   | No. 6        | 0.01       | 0.00                            | 0     | 0.08                     | 0.01      | 6     |                          |
|   | No. 7        | 0.01       | 0.00                            | 0     | 0.04                     | ...       | ...   |                          |
|   | No. 8        | 0.01       | 0.01                            | 47    | 0.16                     | 0.03      | 8     |                          |
|   | No. 9        | 0.02       | 0.00                            | 0     | 0.15                     | 0.02      | 6     |                          |
|   | No. 10       | 0.01       | 0.00                            | 0     | 0.02                     | 0.00      | 0     |                          |
|   | No. 11       | 0.02       | 0.01                            | 24    | ...                      | ...       | ...   |                          |
|   | Average..... | 0.01       | 0.00                            | 39    | 0.08                     | 0.02      | 11    |                          |
| Lab.-to-Lab. values.....  | ...          | 0.01       | 46                              | ...   | 0.16                     | 74        |       |                          |
| No. 5<br>(Na <sub>2</sub> O = 0.99,<br>K <sub>2</sub> O = 0.38) | No. 1        | 0.05       | 0.02                            | 16    | 0.24                     | ...       | ...   |                          |
|   | No. 2        | 0.02       | 0.00                            | 0     | 0.09                     | 0.04      | 19    |                          |
|   | No. 3        | 0.03       | 0.01                            | 16    | 0.21                     | 0.09      | 19    |                          |
|   | No. 4        | 0.04       | 0.00                            | 0     | 0.27                     | ...       | ...   |                          |
|   | No. 6        | 0.03       | 0.01                            | 16    | 0.23                     | 0.07      | 12    |                          |
|   | No. 7        | 0.01       | 0.01                            | 47    | 0.02                     | ...       | ...   |                          |
|   | No. 8        | 0.04       | 0.01                            | 12    | 0.24                     | 0.03      | 5     |                          |
|   | No. 9        | 0.04       | 0.00                            | 0     | 0.31                     | 0.03      | 5     |                          |
|   | No. 10       | 0.02       | 0.01                            | 24    | 0.08                     | 0.04      | 20    |                          |
|   | No. 11       | 0.03       | 0.01                            | 16    | ...                      | ...       | ...   |                          |
|   | Average..... | 0.03       | 0.01                            | 15    | 0.19                     | 0.05      | 13    |                          |
| Lab.-to-Lab. values.....  | ...          | 0.04       | 38                              | ...   | 0.29                     | 49        |       |                          |
| No. 6<br>(Na <sub>2</sub> O = 0.05,<br>K <sub>2</sub> O = 1.30) | No. 1        | 0.04       | 0.01                            | 12    | 0.25                     | ...       | ...   |                          |
|   | No. 2        | 0.02       | 0.00                            | 0     | 0.16                     | 0.04      | 12    |                          |
|   | No. 3        | 0.02       | 0.00                            | 0     | 0.26                     | 0.03      | 5     |                          |
|   | No. 4        | 0.03       | 0.01                            | 16    | 0.25                     | ...       | ...   |                          |
|   | No. 6        | 0.03       | 0.01                            | 16    | 0.18                     | 0.03      | 7     |                          |
|   | No. 7        | 0.02       | 0.00                            | 0     | 0.04                     | ...       | ...   |                          |
|   | No. 8        | 0.04       | 0.02                            | 20    | 0.32                     | 0.07      | 9     |                          |
|   | No. 9        | 0.03       | 0.00                            | 0     | 0.29                     | 0.03      | 5     |                          |
|   | No. 10       | 0.02       | 0.00                            | 0     | 0.02                     | 0.01      | 24    |                          |
|   | No. 11       | 0.03       | 0.01                            | 16    | ...                      | ...       | ...   |                          |
|   | Average..... | 0.03       | 0.01                            | 8     | 0.20                     | 0.04      | 10    |                          |
| Lab.-to-Lab. values.....  | ...          | 0.02       | 27                              | ...   | 0.30                     | 50        |       |                          |

TABLE IV.—STATISTICAL ANALYSIS.  
Aggregate No. 5—Pure limestone and 10 per cent siliceous magnesian limestone.

| Cement  | Laboratory    | Expansion at Various Ages, per cent |       |                          |          |       |                          |          |       |                          |          |       |                          |
|---|---------------|-------------------------------------|-------|--------------------------|----------|-------|--------------------------|----------|-------|--------------------------|----------|-------|--------------------------|
|   |               | 8 Weeks                             |       |                          | 12 Weeks |       |                          | 16 Weeks |       |                          | 52 Weeks |       |                          |
|   |               | Average                             | Range | Coefficient of Variation | Average  | Range | Coefficient of Variation | Average  | Range | Coefficient of Variation | Average  | Range | Coefficient of Variation |
| No. 4<br>(Na <sub>2</sub> O = 0.53,<br>K <sub>2</sub> O = 0.36) | No. 1         | 0.35                                | 0.06  | 8                        | 0.47     | 0.08  | 7                        | 0.58     | 0.11  | 8                        | 1.01     | ..    | ..                       |
|   | No. 2         | 0.16                                | 0.04  | 9                        | 0.21     | 0.06  | 12                       | 0.26     | 0.06  | 10                       | 0.38     | 0.13  | 16                       |
|   | No. 3         | 0.25                                | 0.02  | 2                        | 0.35     | 0.04  | 4                        | 0.42     | 0.06  | 6                        | 1.03     | 0.14  | 6                        |
|   | No. 4         | 0.41                                | 0.03  | 3                        | ..       | ..    | ..                       | 0.67     | 0.02  | 1                        | 1.09     | ..    | ..                       |
|   | No. 6         | 0.23                                | 0.07  | 14                       | 0.27     | 0.08  | 13                       | 0.34     | 0.07  | 10                       | 0.85     | 0.27  | 13                       |
|   | No. 7         | 0.22                                | 0.06  | 12                       | 0.28     | 0.08  | 12                       | 0.35     | 0.08  | 9                        | 0.69     | ..    | ..                       |
|   | No. 8         | 0.33                                | 0.03  | 4                        | 0.44     | 0.06  | 6                        | 0.54     | 0.07  | 6                        | 1.04     | 0.12  | 5                        |
|   | No. 9         | 0.23                                | 0.05  | 9                        | 0.32     | 0.06  | 8                        | 0.41     | 0.07  | 7                        | 1.02     | 0.07  | 4                        |
|   | No. 10        | 0.24                                | 0.06  | 11                       | 0.30     | 0.06  | 9                        | 0.35     | 0.08  | 10                       | 0.68     | 0.18  | 12                       |
|   | No. 11        | 0.26                                | 0.03  | 4                        | 0.37     | 0.02  | 2                        | 0.44     | 0.02  | 2                        | ..       | ..    | ..                       |
|   | Average ..... | 0.27                                | 0.04  | 8                        | 0.34     | 0.06  | 8                        | 0.44     | 0.06  | 7                        | 0.86     | 0.15  | 9                        |
| Lab.-to-Lab. values .....                                       | ..            | 0.35                                | 26    | ..                       | 0.26     | 23    | ..                       | 0.41     | 27    | ..                       | 0.61     | 26    |                          |
| No. 5<br>(Na <sub>2</sub> O = 0.99,<br>K <sub>2</sub> O = 0.38) | No. 1         | 0.50                                | 0.02  | 1                        | 0.57     | 0.03  | 2                        | 0.61     | 0.03  | 2                        | 0.64     | ..    | ..                       |
|   | No. 2         | 0.47                                | 0.08  | 6                        | 0.57     | 0.06  | 5                        | 0.57     | 0.07  | 5                        | 0.61     | 0.05  | 4                        |
|   | No. 3         | 0.30                                | 0.01  | 2                        | 0.34     | 0.04  | 5                        | 0.37     | 0.06  | 7                        | 0.38     | 0.08  | 8                        |
|   | No. 4         | 0.50                                | 0.04  | 4                        | ..       | ..    | ..                       | 0.62     | 0.06  | 4                        | 0.70     | ..    | ..                       |
|   | No. 6         | 0.36                                | 0.06  | 6                        | 0.40     | 0.06  | 7                        | 0.44     | 0.07  | 7                        | 0.53     | 0.03  | 3                        |
|   | No. 7         | 0.53                                | 0.10  | 9                        | 0.63     | 0.09  | 6                        | 0.67     | 0.09  | 6                        | 0.68     | ..    | ..                       |
|   | No. 8         | 0.58                                | 0.32  | 23                       | 0.64     | 0.33  | 21                       | 0.67     | 0.36  | 22                       | 0.70     | 0.37  | 22                       |
|   | No. 9         | 0.38                                | 0.06  | 6                        | 0.44     | 0.05  | 5                        | 0.48     | 0.05  | 5                        | 0.54     | 0.07  | 5                        |
|   | No. 10        | 0.39                                | 0.09  | 11                       | 0.44     | 0.10  | 10                       | 0.48     | 0.06  | 6                        | 0.53     | 0.07  | 6                        |
|   | No. 11        | 0.25                                | 0.01  | 2                        | 0.33     | 0.05  | 8                        | 0.43     | 0.25  | 26                       | ..       | ..    | ..                       |
|   | Average ..... | 0.42                                | 0.08  | 7                        | 0.48     | 0.09  | 8                        | 0.53     | 0.11  | 9                        | 0.59     | 0.11  | 8                        |
| Lab.-to-Lab. values .....                                       | ..            | 0.33                                | 24    | ..                       | 0.31     | 23    | ..                       | 0.30     | 19    | ..                       | 0.32     | 15    |                          |
| No. 6<br>(Na <sub>2</sub> O = 0.05,<br>K <sub>2</sub> O = 1.30) | No. 1         | 0.58                                | 0.08  | 6                        | 0.66     | 0.12  | 7                        | 0.70     | 0.10  | 6                        | 0.71     | ..    | ..                       |
|   | No. 2         | 0.66                                | 0.06  | 4                        | 0.78     | 0.06  | 3                        | 0.84     | 0.08  | 4                        | 0.92     | 0.11  | 5                        |
|   | No. 3         | 0.67                                | 0.04  | 2                        | 0.73     | 0.04  | 2                        | 0.77     | 0.05  | 3                        | 0.84     | 0.05  | 2                        |
|   | No. 4         | 0.65                                | 0.04  | 3                        | ..       | ..    | ..                       | 0.87     | 0.09  | 5                        | 1.01     | ..    | ..                       |
|   | No. 6         | 0.65                                | 0.10  | 7                        | 0.70     | 0.10  | 7                        | 0.73     | 0.11  | 7                        | 0.83     | 0.09  | 5                        |
|   | No. 7         | 0.49                                | 0.04  | 4                        | 0.58     | 0.04  | 3                        | 0.64     | 0.04  | 3                        | 0.69     | ..    | ..                       |
|   | No. 8         | 0.76                                | 0.09  | 5                        | 0.87     | 0.08  | 4                        | 0.94     | 0.08  | 4                        | 1.03     | 0.11  | 4                        |
|   | No. 9         | 0.50                                | 0.07  | 5                        | 0.59     | 0.07  | 5                        | 0.63     | 0.05  | 4                        | 0.69     | 0.07  | 4                        |
|   | No. 10        | 0.52                                | 0.06  | 5                        | 0.58     | 0.10  | 7                        | 0.60     | 0.14  | 10                       | 0.64     | 0.15  | 10                       |
|   | No. 11        | 0.46                                | 0.05  | 5                        | 0.50     | 0.05  | 4                        | 0.52     | 0.08  | 6                        | ..       | ..    | ..                       |
|   | Average ..... | 0.60                                | 0.06  | 5                        | 0.67     | 0.07  | 5                        | 0.72     | 0.08  | 5                        | 0.82     | 0.10  | 5                        |
| Lab.-to-Lab. values .....                                       | ..            | 0.30                                | 16    | ..                       | 0.21     | 16    | ..                       | 0.42     | 17    | ..                       | 0.39     | 17    |                          |

No. 1 or 2 combined with the most active of the aggregates up to 52 weeks age. Cement No. 1 contained 0.13 per cent soda equivalent ( $\text{Na}_2\text{O}$  + 0.658  $\text{K}_2\text{O}$ ) and No. 2 contained 0.40 per cent. With cements Nos. 3, 4, and 6 a general trend of greater expansions with increasing alkali content is evident, but cement No. 5, with the highest soda equivalent, produced less expansion than either cement No. 4 or cement No. 6 at 52 weeks.

The results of individual laboratories are again compared in Fig. 3 wherein the expansion at various ages to 52 weeks is shown for cement No. 6 and aggregate No. 4. This figure may be considered typical of most of the expansive combinations. It may be seen that, while the laboratories were not in agreement on the amount of expansion at any age, within eight weeks all would have pronounced this combination decidedly reactive. Most laboratories would have reached this conclusion within four weeks. These statements would be true for all combinations of the two reactive aggregates with the two cements of highest alkali content. With cement No. 4 (0.53 per cent  $\text{Na}_2\text{O}$  and 0.36 per cent

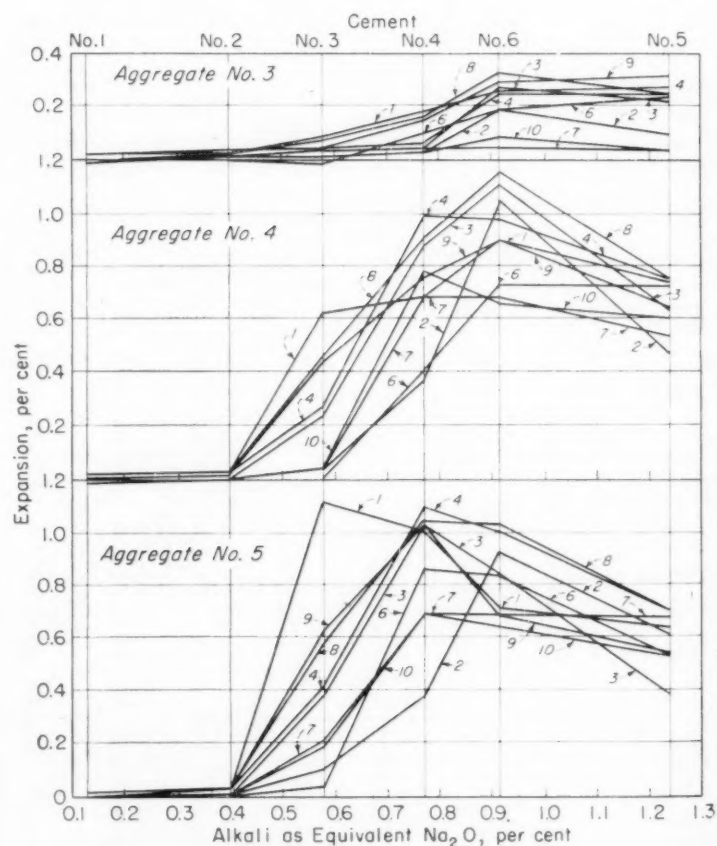


Fig. 2.—Expansion at 52 Weeks as Related to Alkali Content of Cement.  
Cement number is noted at its alkali content. Each curve shows the average expansion for a laboratory, bearing the number appearing in Tables II, III, and IV.



K<sub>2</sub>O) and aggregate No. 4 a slightly longer period was required to conclude that the combination was expansive; however, all laboratories were in final agreement on this point.

Referring to Table II, the reader will observe that two laboratories (7 and 10) failed to find material expansion with the crushed White River gravel even after 52 weeks. The other laboratories did obtain significant reaction between this aggregate and the cements of highest alkali content at the end of this period. However, with cement No. 4, few of them obtained appreciable expansion. Mr. Tremper has found this White River gravel to give poor service when used with a high alkali cement. It appears, therefore, that the mortar bar expansion test, as performed in this series of tests, should be continued for a period approaching one year to insure that any potential expansive reaction is finally revealed. It is also indicated that a single experiment may fail to show that suspected material is actually reactive, and that a cement containing 1 per cent alkalis (soda equivalent) or more should be used in the test.

Many experimenters have found that the mortar bar expansion test may be accelerated by storing the specimens at an elevated temperature. The 70 F. storage used in this series was adopted because all participating laboratories had facilities for storing at such a controlled temperature. No doubt, the White River gravel would have shown greater expansion, and at an earlier period, if the test had been made at a higher temperature. However, some experimenters have found that an optimum temperature exists at about 110 F., above which less expansion is produced.

The mortar bar expansion test has been shown in this cooperative series to reveal, within a reasonable period of time, and in some cases very quickly, whether or not aggregates are highly reactive with high-alkali cement. If the aggregate is moderately reactive or slowly reactive, the mortar bar expansion test may require a considerable period to register the potential expansion. In these cases, dependence upon a single test may be hazardous, since it has been shown that the coefficient of variation for the mortar bar expansion test is very high.

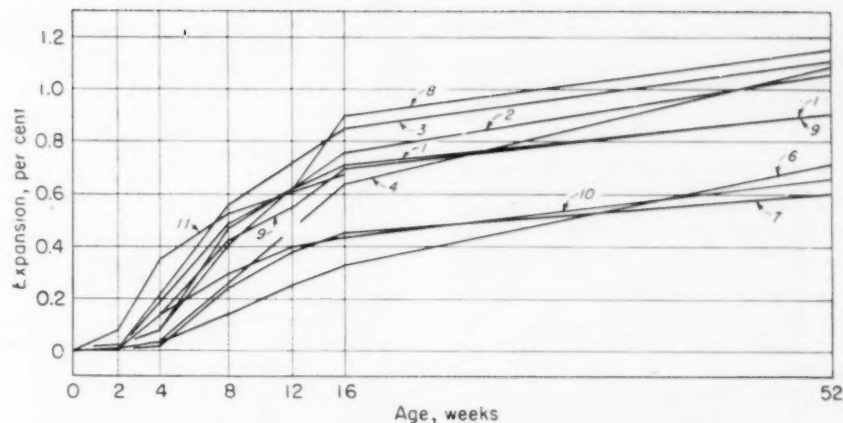


Fig. 3.—Comparison of Expansion Among Laboratories.

Cement No. 6 (0.5% Na<sub>2</sub>O and 1.30% K<sub>2</sub>O).  
Aggregate No. 4—Perkins sand and 10% Siliceous Magnesian Limestone.  
Each curve shows the average expansion for a laboratory, bearing the number appearing in Table III.

cient of variation for the mortar bar expansion test is very high.

It would seem that many of the apparently conflicting results that have been experienced by laboratories working on this problem may be explained by the lack of accuracy demonstrated for the test in this cooperative series. To establish an absolute figure for the expansion of a given combination of reactive aggregate and cement at any age would require that the test be repeated many times by different laboratories which is obviously impracticable. Further, it appears that the magnitude of expansion secured from single tests should be used cautiously for interpreting experimental results, and that such interpretation should not be made unless repeated tests substantiate the original conclusions.

#### CONCLUSIONS

1. No material expansions were obtained by any of the cooperating laboratories when using the reactive aggregates in this series with a cement containing 0.40 per cent soda equivalent (Na<sub>2</sub>O + 0.658 K<sub>2</sub>O) or less. With cements containing 0.58 per cent soda equivalent or more, a general trend of greater expansions with increased alkali content was evident.

2. The laboratory-to-laboratory coefficients of variation for the mortar bar expansion test are much larger than usually encountered in acceptable test work. This cooperative series, therefore, indicates that the amount of expansion secured

from a single test is not entirely reliable and cannot be accurately reproduced.

3. It appears that the large variations found in the results are inherent in the test and that refinements in technique and procedures, beyond the usual care taken by most laboratories and as taken in this cooperative investigation, would be necessary to improve its accuracy.

4. A single test with any given aggregate and cement combination cannot be relied upon to give an accurate figure for the amount of expansion to be expected from such a combination at any age. It can be relied upon to determine whether or not an aggregate is highly reactive. In the case of mildly or slowly reactive aggregates, a single test cannot be depended upon to reveal their activity; however, if sufficient specimens containing cement in excess of 1 per cent alkalis (soda equivalent) are made from different batches of mortar and are observed for a sufficiently long period the test can be relied upon to reveal their activity.

#### Acknowledgments:

The working committee desires to acknowledge the assistance of the National Bureau of Standards, the Portland Cement Association, the Public Roads Administration, and the New Jersey State Highway Department in this cooperative study. Acknowledgment is also made to H. S. Meissner and T. V. Woodford for assistance in the analysis of data and preparation of this report.

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## Dielectric Strength Measurements on Varnished Cambric

An Investigation of Several Factors to Determine Their Effects on the Measured Dielectric Strength of Varnished Cambric Insulation

By A. Rufolo<sup>1</sup> and H. K. Graves<sup>1</sup>

THE determination of dielectric strength of an insulating material has always been complicated by the presence of several factors known to exert considerable influence on results obtained. It has been accepted practice to control these effects as much as possible by using standard procedures. Consequently, while standardization may be reasonably successful in establishing a basis for comparison among investigators, the degree and range of effects produced by these factors may remain relatively unexplored. Using varnished cambric samples, the effects of three of these factors, namely, humidity, electrodes, and breakdown media, were studied as an approach to the general problem.

The samples obtained included four thicknesses of black varnished cambric cloth, both bias and straight-cut, representing five manufacturers. Several samples of yellow varnished cambric were also obtained. The range of the study was further restricted to include only those methods believed to be currently specified or in use in the various laboratories. The investigation was conducted with three types of electrodes, for two pre-test conditions and with breakdowns made in two media.

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Certain other considerations which prompted the use of this general procedure are worthy of discussion. The 2-in. diameter electrodes were selected as being the most satisfactory for dielectric strength tests on varnished cambric cloth since they cover a relatively large area of sample and permit a reasonably large radius of curvature at the edges to minimize voltage stress concentration. The  $\frac{1}{4}$ -in. diameter electrodes have been used for many years in the testing of varnished cambric and possess the advantage of being equally applicable to both cloth and narrow tapes, but they have the disadvantage of higher stress concentration at the edges. The  $\frac{1}{4}$  by 4-in. rectangular electrodes have also been standard for testing of other types of insulating tapes, have stress concentration comparable to that of the  $\frac{1}{4}$ -in. electrodes and have the advantage of being applicable to both cloth and narrow tapes, but, unlike  $\frac{1}{4}$ -in. electrodes, have a much higher specimen coverage. A tabulation of electrode dimensions to outline some of the variables involved might be set up as follows:

| Electrode size, in.....               | $\frac{1}{4}$ | $\frac{1}{4}$ by 4 | 2        |
|---------------------------------------|---------------|--------------------|----------|
| Shape.....                            | Circular      | Rectangular        | Circular |
| Area, sq. in.....                     | 0.049         | 1.0                | 3.14     |
| Perimeter, in.....                    | 0.785         | 8.8                | 6.28     |
| Radius of curvature at edges, in..... | 0.031         | 0.031              | 0.25     |

The two conditioning humidities were chosen because they were readily attainable in any laboratory and represented extremes of low and high humidity without, however, exceeding possible service conditions.

Since there has been some controversy on the relation of dielectric breakdown measured in air to that measured with the sample immersed in transformer oil, comparative tests were run in the two media. However, only the smaller size electrodes were used to avoid the necessity of conditioning and breaking down large specimens.

### TEST EQUIPMENT

A dial type micrometer, calibrated to 0.0001 in. with 2-in. diameter anvil and  $\frac{1}{4}$ -in. diameter presser foot under a 3-oz. dead weight, was used for all thickness measurements.

Breakdowns above 3000 v. were made on a 2-kva. transformer with a 4-coil secondary and switching arranged to give full-scale readings of 7500, 15,000, or 30,000 v. Below 3000 v. (nearly all the high humidity samples) breakdowns were made on a 3-kva. transformer with a single secondary winding. Voltmeters connected to tapped tertiary windings were used on both transformers to indicate breakdown voltages. Voltage rise in each case was manually controlled by means of variable auto-transformers.



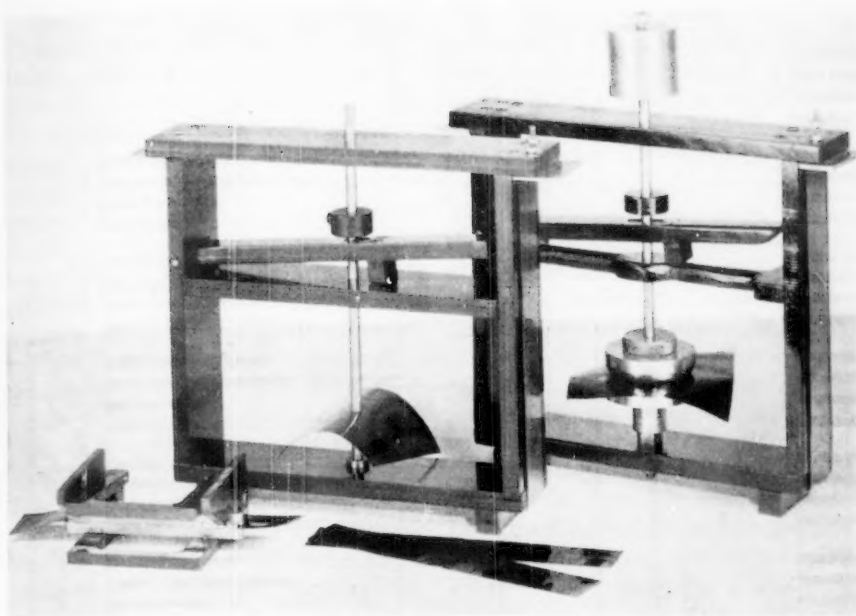


Fig. 1.—The Three Types of Electrodes Used for the Investigation.

The three types of electrodes, shown in Fig. 1, may be briefly described as follows:

(a) 2-in.—Polished brass disks, 2 in. in diameter and  $\frac{1}{2}$  in. thick, having edges in contact with the sample rounded to a  $\frac{1}{4}$ -in. radius. Faces self-aligning with 1.5-lb. pressure on specimens.

(b)  $\frac{1}{4}$  by 4-in.—Polished brass bars  $\frac{1}{4}$  in. wide, 4 in. long, and  $\frac{1}{4}$  in. thick, with ends rounded to a  $\frac{1}{8}$ -in. radius parallel to the sample and with edges of contact faces rounded to a  $\frac{1}{32}$ -in. radius. Faces self-aligning with 1-lb. pressure on specimens.

(c)  $\frac{1}{4}$ -in.—Polished brass rods  $\frac{1}{4}$  in. in diameter having edges in contact with specimen rounded to a  $\frac{1}{32}$ -in. radius. Rigidly held in alignment with 1-lb. pressure on specimens.

Standard sealed desiccators were used for conditioning of specimens. Anhydrous calcium chloride was used for the dry condition to produce a relative humidity of less than 10 per cent, and saturated solutions of potassium sulfate were used to produce the 96 per cent relative humidity. A temperature of 25 C. was maintained for the entire conditioning period.

#### TEST SPECIMENS

Samples used for the test were taken from rolls stored for several

weeks at 25 C. and 50 per cent relative humidity. Materials were in nominal thicknesses of 5, 7, 10, and 12 mils, bias and straight-cut, black and yellow. The specimens used with 2-in. electrodes were cut 3 in. square and those used with the  $\frac{1}{4}$  by 4 in. were cut into 1 by 7-in. rectangles. Specimens used with the  $\frac{1}{4}$ -in. electrodes were 6 in. square for tests in air and 1 by 7 in. for tests in oil.

#### TEST PROCEDURE

All testing was carried on under controlled room conditions of 25 C. and 50 per cent relative humidity. Complete tests were made on one sample cloth before starting another and samples awaiting test were stored in the rolls at the above conditions.

In starting a test on a sample, sufficient material was removed from the roll to provide the necessary specimens and twenty thickness measurements were made at widely distributed points on this piece prior to cutting specimens. The average of these twenty measurements was used in the calculation of dielectric strength.

Specimens were spaced  $\frac{1}{2}$  in. apart on bent wire racks and placed in the conditioning desiccators. After completion of the 96-hr. conditioning period, specimens were

removed from desiccators in groups of ten, stacked to minimize change in condition, and tested as rapidly as possible. Since dielectric strength involves volume rather than surface characteristics and since there was no discernible progressive change in values from the first to the last of the group of ten specimens, it was assumed that no significant gain or loss of moisture occurred between the time the sample was removed from the desiccator and the time it was tested.

Rate of rise of voltage was manually controlled at 500 v. per second with the aid of an electric stopclock connected in the transformer circuit. Twenty-five individual breakdowns were made on each cloth for each type electrode after each conditioning.

#### RESULTS OF INVESTIGATION

The results of test, in average volts per mil dielectric strength, for each of the 32 samples are presented graphically in Figs. 2 and 3. For interpreting the sample code, numbers represent thickness, capital letters distinguish between manufacturers, and the letters *y* and *b* indicate the color of the sample. Sub-numerals on Fig. 3 (12A<sub>b1</sub> and 12A<sub>b2</sub>) represent two materials from the same manufacturer and having the same nominal thickness and color. The sequence of bars representing results obtained with different electrodes and media is indicated for group 5Bb of Fig. 3 and is consistent for subsequent groups of both charts. The bars represent average dielectric strength of dry specimens and the shaded portions represent dielectric strength of moisture-conditioned samples. Since twenty-five breakdowns were taken in each instance for a single arithmetic average, it is seen that the charts, Figs. 2 and 3, are a compilation of 6400 individual dielectric breakdowns.

An examination of these charts showed certain effects to be consistent for the various samples. It is evident that bars representing results with dry samples followed a definite pattern with electrode and media used. The pattern persists for the thicker moisture-conditioned samples but is somewhat disturbed for the thinner materials.

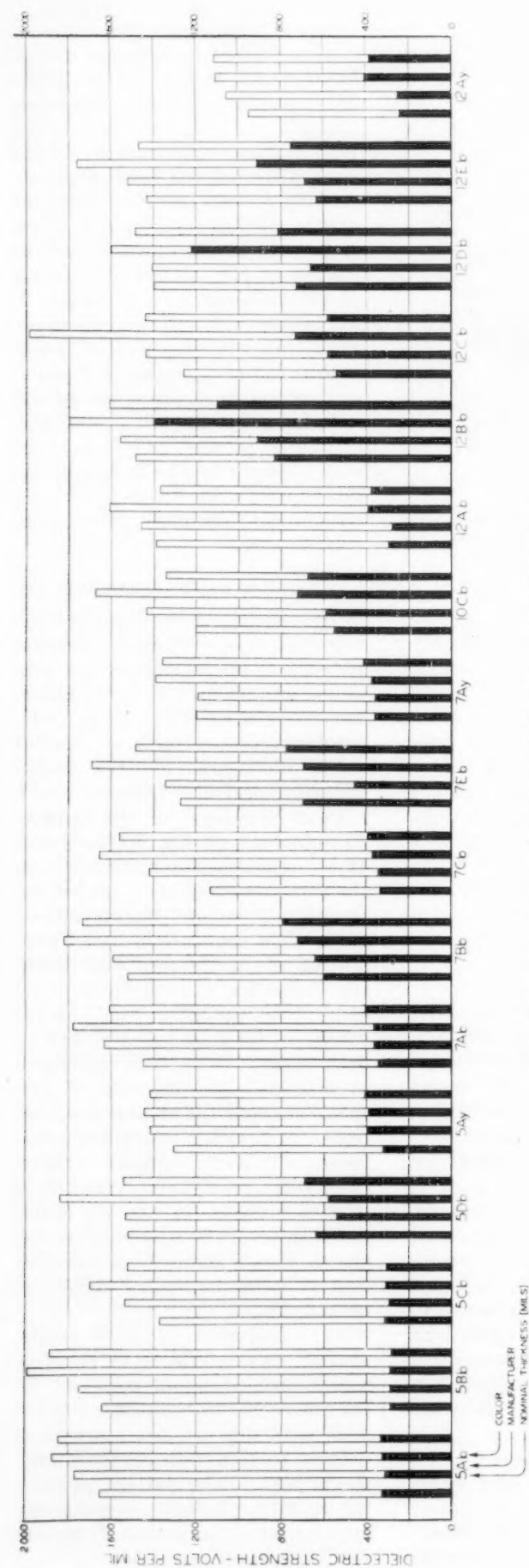


Fig. 2.—Dielectric Strengths of Straight-Cut Varnished Cambrics.

The average dielectric strengths of dried specimens are represented by total bar heights and those of high humidity conditioned specimens, by heights of shaded sections. Twenty-five breakdowns were used to obtain each average.

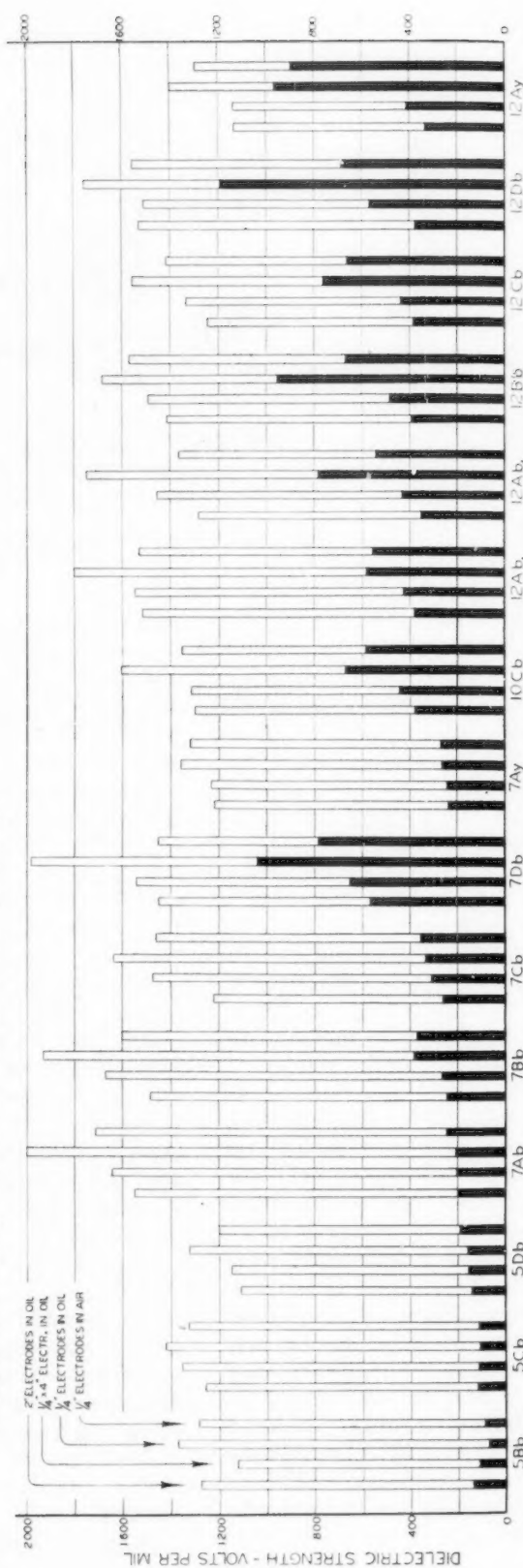


Fig. 3.—Dielectric Strengths of Bias-Cut Varnished Cambrics.

The average dielectric strengths of dried specimens are represented by total bar heights and those of a high humidity conditioned specimens, by heights of shaded sections. Twenty-five breakdowns were used to obtain each average.



The general trend toward lower dielectric strength with increased thickness is evident for dry samples, if 5-mil bias-cut samples are excluded, while a reverse effect is also evident for moisture-conditioned samples. It is also noted that the yellow samples disturbed these trends by yielding generally lower results, but this effect cannot be used as a criterion, since yellows had been supplied by only one manufacturer.

Since it was not possible to obtain samples of the four desired thicknesses and of both colors and cuts from all manufacturers, a considerable unbalance of data resulted. Due to this unbalance, an indiscriminate comparison of all results would lead to erroneous conclusions. It would be misleading, for example, to compare averages of all bias-cut samples with all straight-cut samples when thicknesses, manufacturers, and colors were not equally represented in the two groups; or to determine effect of thickness using all samples when representation of the four nominal thicknesses varied to so great a degree. Furthermore, an attempt was made to evaluate the interactions among factors to enable a quantitative determination of effects attributable to specific factors. Therefore, in making each analysis, the results were arranged in balanced groups and these were then studied, using recognized statistical procedures, to determine the effect of a particular factor. Such analyses were used in drawing the conclusions which follow.

#### CONCLUSIONS

Dielectric strength after moisture conditioning in general was about 75 per cent lower than the dry dielectric strength. This difference varied with thickness, moisture showing less effect (about 60 per cent) on the thicker materials. When considering 12-mil black materials only, it was noted that the bias cut showed a greater effect of exposure to high humidity than the straight cut. There was considerable difference in the effect of humidity on samples from the various manufacturers. On 12-mil material, manufacturer B showed the least loss (about 34 per cent) while manufacturer A showed the greatest (about 78 per cent), indicating

that variations among cuts and thicknesses of cloth would be considerably less than might be expected among manufacturers.

In comparing effect of electrodes and using the 2-in. electrodes as a reference base, the  $\frac{1}{4}$  by 4-in. gave approximately 5 per cent higher dielectric strengths and the  $\frac{1}{4}$ -in. showed results about 27 per cent higher. These variations were more accentuated on the bias than on the straight-cut materials. Increase of measured dielectric strength is of course to be expected with decrease of electrode size. However, it appears from the above that changes in electrode size, as might be caused by ionization of surrounding air, will produce considerable effect on measured dielectric strength with the  $\frac{1}{4}$ -in. diameter electrode, but little effect with the  $\frac{1}{4}$  by 4 in. In other words, a curve of dielectric breakdown *versus* electrode diameter would be very steep at  $\frac{1}{4}$  in., but would have flattened out considerably at  $1\frac{1}{8}$  in. (approximate circular equivalent of  $\frac{1}{4}$  by 4-in. electrode). It is believed, therefore, that results obtained with the larger electrodes would have more value.

Dielectric breakdown measured in air appeared to be about 9 per cent lower than when measured in oil. This conclusion is based only on results obtained with  $\frac{1}{4}$ -in. diameter electrodes. As might be expected, the difference varied with thickness of specimens, increasing as thickness increased.

It should be noted that the scope of the investigation was sufficiently broad to permit studies of factors other than those discussed earlier. An analysis showed, for example, that in general the average dielectric breakdown of bias-cut cloths was about 25 per cent lower than for straight-cut materials. However, a further analysis of presented data was considered too digressive for this article.

It was also recognized that the investigation itself might have followed more extensive lines. For example, it might have been possible to include round electrodes of several diameters but having the same contact edge curvature, so that the effect of electrode area could be studied. It is apparent that such

a study would have involved dry and high humidity conditioned samples of several thicknesses, in air and in oil. Likewise, with electrode area held constant, an investigation of the effect of contact edge curvature could have been included. To restrict the scope of the work to some practical limits, methods believed to be commonly used were studied, as was mentioned previously.

The authors favor the use of 2-in. diameter electrodes because they provide adequate sample coverage with reasonably large contact edge curvature, minimize alignment errors, and may be readily resurfaced. Furthermore, during breakdowns in air, ionization may cause an increase in what might be termed "effective electrode area" and, since this change is dependent on voltage, the net effect is analogous to larger electrodes at high breakdowns than at low breakdowns. It is evident that the smaller the electrode used, the greater the per cent change of "effective electrode area" with voltage. Where use of 2-in. electrodes is not possible, as in testing tapes, this investigation has indicated that the  $\frac{1}{4}$  by 4-in. electrodes may be substituted with little difference in results. However, substitution of oil for air medium, or *vice versa*, does not appear feasible, since results are comparable only at low breakdown voltages, those in air tending to be much lower as breakdown voltages increase. The two humidity conditions were readily maintained and are considered suitably indicative of the effect of high humidity on varnished cambric. In this respect, the use of small chambers, such as glass desiccators, is preferred to large cabinets for maintaining condition and for handling groups of specimens.

In concluding, the authors express the hope that this investigation has attained its objective in presenting a quantitative study of certain factors which commonly affect the determination of dielectric strength of varnished cambric cloth.

#### Acknowledgment:

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# Aims and Objectives for A.S.T.M. Committee D-18 on Soils

By D. M. Burmister<sup>1</sup>

*Editor's Note.*—While this paper relates specifically to the work of Committee D-18, it is of interest not only in discussing the work of that committee but also because the outline presented would have rather general application.

A FEW ideas on objectives are here presented for the consideration of Committee D-18 on Soils for Engineering Purposes to give direction and purpose to our efforts in the immediate future, and to provide a proper perspective of our work. The war has taught us two very important lessons. First of all, real progress in any scientific field can be made only by fostering and developing new ideas and new concepts to their fullest extent. Anything that becomes fixed and static is losing ground. Only by continued efforts to push back the horizons of our knowledge in our search for truth and for better ways of doing things can we keep our work alive and vital, and abreast of progress. Second, real progress can be made only by teamwork and close cooperation of all interested. Every effort should be made to reconcile divergent viewpoints, or to come to agreements by an intelligent give and take, and a real desire to cooperate. Thus a greater emphasis should be placed on fundamental research to advance the science of soils, and on teamwork to get things done.

The greatest potential field of progress in Soils Engineering lies in the direction of the accumulation of detailed accurate information on the physical properties of soils, and on their behavior under the varied conditions encountered in practice. The classification systems now in use, defining the soil components and soil classes quite differently, are not as generally useful as they should be to people who would like to use this information, but who are not conversant with the particular system used.

In the interest of greatest progress in Soils Engineering, and in order to make the information on soils of greatest practical use to all who wish

to use it, there are three important objectives which we should seek to achieve in the near future. These objectives should follow a logical sequence. The first objective should be to provide a common ground of understanding by coming to some definite agreement on the basic problem of the *Definition of Soil Components* which would be reasonably acceptable to all concerned. The second objective should be to establish a common language for describing soils, sufficiently accurate and precise, yet expressed in simple engineering and technical terms, that are readily understood by a boring foreman, contractor, foundation engineer, highway engineer in any part of the country, as well as by an expert in soil mechanics. This language will have to be more precise than local names of soils in use. The third objective should be to group soils into classes, which have in common similar physical characteristics. But we need something far more basic than any of the present attempts at classification of soils, which relate only to a special field of application. The basic classification should provide a common ground of understanding and be expressed in a common language, so that all working in the field of soils engineering may use it.

This concept of a basic classification is well illustrated by an analogy suggested by Prof. Hamilton Gray (University of Maine): "Depending upon the viewpoint of the user, wood may be classified with respect to (a) strength, (b) workability, (c) decay resistance, (d) fuel value, (e) figure or grain, etc. While it is usually observed that a wood with high strength has a high fuel value, strength may mean nothing relative to its decay resistance or its figure or grain. Hence, one method of classification has no significant bearing upon another application of the same material. The basic classi-

fication of woods is botanical. The botanist identifies his species by means of the shape of the leaf, the size and shape of the tree, and the nature of the bark. This forms the basis of classification, which is therefore an absolutely satisfactory classification, because people have learned to identify the properties and characteristics of woods in which they are interested with the botanical name."

In a similar way, soils should be identified and given a descriptive name, which is expressed in simple engineering and technical terms, and based upon the universally comprehended terms of grain size and plasticity. Soils may then be grouped into classes in accordance with the basic classification. The man working in a particular field can draw his own conclusions and interpret this information in terms of his own particular experience regarding the behavior of the different classes of soils.

Let us consider next the general objectives in soil sampling and testing, as compared with the objectives in the sampling and testing of the common structural materials. The principal objective, almost without exception, for the common structural materials is to determine whether a manufactured or a processed product meets certain requirements and specifications as to quality, uniformity, and workmanship. The results of tests are used primarily as the basis for the acceptance or rejection of a product. The physical properties of the common structural materials are generally uniform, and are relatively simple and constant, and their determination involves no important elements of uncertainty. The standard A.S.T.M. tests are therefore simple and straightforward and sufficiently detailed so that they can be easily followed. These tests do not involve, in general, any element of judgment.

On the other hand, the objectives in soil sampling and testing are radically different in certain important respects. Nature supplies us with soils of widely varying

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character, which are never made to order. We expect every sample of soil to be different, frequently in important respects. The physical properties of soils are not generally uniform or simple, but are markedly affected by external conditions, notably by variations in moisture content, and by the stress conditions imposed upon them. The determination of the physical properties of soils is not a simple matter, and involves important uncertainties as to whether the values obtained for the properties really have a significant and direct bearing upon the solution of practical problems in soils engineering.

The principal problem is to make the most effective use of the soils which nature supplies in any given case. The principal objective in soil testing is to obtain reliable and accurate values for the physical properties of soils, which will have a direct and significant bearing upon the solution of practical problems in soils engineering. Because of the varied types of problems and of soil conditions likely to be encountered, every soil test partakes of the nature of a research problem, and important elements of judgment are involved regarding the exact technique to be used for a particular case. This research approach to the problems of soil testing is fundamental and is realistic.

#### SOIL TESTING

Soil tests may be divided into four broad categories as follows:

1. Routine identification tests.
2. Control tests.
3. Physical property tests for strength, permeability, etc.
4. Tests in place for bearing capacity of footings and piles, etc.

##### 1. Routine Identification Tests:

The routine tests, such as the grain size analysis by sieve and hydrometer, the consistency tests for clayey soils, density tests for cohesionless soils, specific gravity tests, etc., are used principally to determine the physical characteristics of soils for the purpose of identification. The results of these tests are, in general, qualitative and more or less arbitrary in character, because they represent the influence and interaction of several physical properties, which cannot be isolated. Rather detailed test procedures are

necessary in order to obtain results that are reasonably consistent and reproducible. But refinements beyond this point are usually not warranted.

Although the test procedures now in use for the routine identification tests are reasonably satisfactory, an important objective should be to develop these routine tests further, or to develop entirely new tests by fundamental research to the point where the results are more quantitative in character and have a more direct bearing on the solution of practical problems. Furthermore, the testing procedures should give a wider latitude for adapting soil testing technique to particular conditions, when they occur, so that the results are more significant.

##### 2. Control Tests:

The control tests include such tests as the moisture-density tests, California Bearing Ratio test, field density tests, water absorption and swell tests, tests for soil-bituminous mixtures, and tests for soil-cement mixtures. These control tests are used in two distinct ways. First, they are used as research tests to determine the best methods of treatment of soils from a given project, and to furnish the necessary information for field control as to quality and uniformity during construction. Second, these tests are used as field control tests in the construction of highways, airport runways, embankments, and earth dams, either to check the quality and uniformity of the processed soil or to furnish the information required for making adjustments in the construction methods in the field, as soil and other conditions change with the progress of the work.

The objectives as field control tests are similar in certain respects to those for the common structural materials, namely, to determine the quality and uniformity of a processed product. Therefore, rather detailed testing procedures are necessary. The objective for the original research on the soils from a given project are entirely different, namely, to learn enough about the nature and behavior characteristics of the soils so as to know how to handle and treat them in the most satisfactory and economical way.

An important objective in the preliminary research work should be to determine what modifications of the usual standard test procedures are necessary or desirable in a particular case, so that the field control tests may be more significant, and have a more direct bearing on actual field conditions encountered on a given project. To satisfy these basic needs, the standard test procedures should be modified to the extent of giving rather broad recommendations as to testing apparatus and test procedures, which permit a somewhat wider latitude in their adaptation suitable to the particular case. The objective should be to develop the testing apparatus and testing procedures so that the results can be expressed in significant physical units, which are independent of the size, shape, and other characteristics of the testing apparatus.

##### 3. Physical Tests for Strength, Permeability, etc.:

This group of tests includes the consolidation test, unconfined compression test, direct shear test, tri-axial compression test, permeability test, etc. These tests are intended to provide essential information on the important stress-strain-time relationships of soils, the compressive strength and shearing strength of soils, the failure conditions, and the drainage characteristics of soils. The results are quantitative in character and are used for specific design purposes. The principal objectives of these soil tests are to obtain significant values for these properties and relationships, which have a direct application to the solution of practical problems of foundation and earthwork engineering.

Mr. L. A. Palmer of the Bureau of Yards and Docks, in commenting upon the consolidation test method, has given practical ideas which apply equally well to this whole group of soil tests. Quoting in part, he states that test methods should describe general procedures, which are designed to obtain essential data, but which give a wide latitude to the laboratory without restricting it to a specific procedure or type of equipment. This feature is particularly desirable, he goes on to say,

because, where varied types of problems and of soil conditions are encountered in foundation work, it is necessary in many cases to utilize different procedures suitable to the particular case. Broad recommendations should be made with full appreciation of the diverse problems of the soils laboratory and of the soils engineer.

In a very real sense, every soil test to determine the strength and other important physical properties of soils becomes a research problem. This approach to soil testing is basic and is realistic. The primary problem of soil testing technique is to obtain a reasonable degree of consistency and uniformity in the results of a series of tests made upon specimens selected from the same sample. It is misleading to state that any of these tests is simple and easily performed and to suggest that any one, without regard to his experience in soil testing or background in soil mechanics, can follow a method of test and obtain results which are significant and have any practical value for the solution of practical problems. Soil testing appears to be simple only to the inexperienced. The more one learns about soil testing and about the practical applications of the results of soil tests, the more he will appreciate and realize the real difficulties involved even in the simplest soil tests, the imperfections and defects in soil testing equipment and testing methods, and the fact that no two soils can be treated exactly alike and obtain significant results.

It will be next to impossible and even undesirable to write test procedures in such detail as to cover explicitly and adequately all of the possible test conditions that may have to be satisfied for the varied types of problems and of soil conditions likely to be encountered in practice. The term *Test Conditions* is to be preferred in this sense, because it connotes broad recommendations of principles. The exact technique to be followed in each case is a matter of experience and judgment.

It will always be necessary for the investigator to analyze and size up for himself each situation before starting a series of tests. This

means that either he must adequately acquaint himself with the nature of each problem or situation, and obtain, in so far as possible, the necessary information on subsurface conditions, stress conditions imposed by the proposed structure or work, or failure conditions that are likely to govern in any given case, so that he can intelligently set up the necessary test conditions; or he must rely on others to state for him completely the necessary test conditions to be followed in any given case. In the first instance, it is a problem of adjusting the testing technique to satisfy the test conditions as he visualizes them. This requires the exercise of good judgment, a thorough knowledge of the basic principles of soil mechanics, and a broad experience in soil testing. In the second instance, it will require considerable experience in soil testing to carry out successfully the specified test conditions, so as to obtain significant values from the tests.

A test method consisting of broad recommendations of test conditions only may appear to be quite unsatisfactory to many people, who are accustomed to following detailed testing procedures, in which little or no element of judgment is involved. It is desirable and essential to obtain a reasonable uniformity and consistency in the results of a series of tests on a given material, even by different investigators. But this should be achieved, not so much by detailed specifications as to type of apparatus and testing procedures, as by satisfying certain definite and essential test conditions which have been set up for a particular situation within the basic framework of the broad recommendations of the test method. An important objective should be to improve the testing equipment for this group of tests, so that the apparatus is free of defects that tend to limit the usefulness and application of the results of the tests, and so that the tests yield results that can be expressed in physical units independent of the size, shape, and other features of the testing apparatus.

Finally, it must be emphasized that in order for the soils engineer properly to interpret the results of

the tests and in order to apply these results correctly in the solution of practical problems of soils engineering, the test results must be accompanied in every case by a concise clear statement of the essential test conditions used that bear directly upon the interpretation and use of the data.

#### 4. *Tests of Soils in Place for Bearing Capacity:*

The tests for bearing capacity appear to be the most direct means of obtaining significant information for design purposes. In many cases they approach full-scale tests; in other cases they are small-scale tests. Before any adequate testing methods can be developed, it will be necessary to learn a great deal more about the nature of the problem, particularly as affected by soil conditions. A test method to be of practical use must permit a reasonable reliability in extrapolation of small-scale loading test data for making estimates of the values of bearing capacity to be used for the full-scale structure. The important objective is not only to develop a testing procedure, but also the interpretation of the data, so that the method will have a direct application to design problems in foundation engineering.

The greatest potential field of progress in soils engineering lies, first of all, in the direction of the accumulation, interpretation, and wide dissemination of information and data on all phases of the work of this committee, and, second, lies in the direction of fundamental research to determine the best ways of doing things.

#### Book on Methods of Testing Soils

Late in 1944 the Society published a 206-page compilation of the soil testing methods standardized by Committee D-18 and included 38 other suggested tests for soil and soil mixtures. A number of these tests are referred to above. This compilation can be procured from A.S.T.M. Headquarters at \$2.25 per copy.



# New Design of Elastic Proving Bar<sup>1</sup>

By C. G. Lutts<sup>2</sup> and Dante Cuozzo<sup>3</sup>

## SYNOPSIS

A new design of elastic proving bar is described whereby elongation is measured centrally along the axis, thus automatically giving average elongation with a single reading. This is in contrast to conventional proving bars where surface measurements are needed at four or more points around the circumference. Preliminary calibration data to a load of 200,000 lb. are also presented.

PROVING bars have for many years been an accepted means for verifying testing machines.<sup>3,4</sup> For example, at the Boston Naval Shipyard in 1920, a proving bar was used to verify the 2,000,000-lb. anchor chain testing machine. The bar used for this purpose was of solid cylindrical section with eye ends, and had been standardized in terms of the 2,300,000-lb. Emery machine at the National Bureau of Standards. It is interesting to recall in connection with these tests that mechanical strain gage readings were made at four points 90 deg. apart around the bar and that appreciable variations were experienced in the strain gage readings at the four positions. Presumably, some slight unavoidable eccentricity in loading caused these variations in surface readings; however, the average value was used and the result was considered satisfactory at that time.

In order to eliminate the need for making a number of surface readings, a new type of proving bar has recently been designed and tested at the Boston Naval Shipyard employing a unique feature for measuring elastic movements. With the new bar, measurements are made along the central axis and thereby inherently greater accuracy and simplicity are afforded as com-

ing, while Figs. 2 and 3 give details. The bar is a straight member with a reduced cylindrical section 30 in. long and 3.047 in. in diameter. A hole 0.4375 in. in diameter, bored axially the length of the bar, contains a steel actuating rod 0.365 in. in diameter. A thumb screw which is threaded into one end of the bar

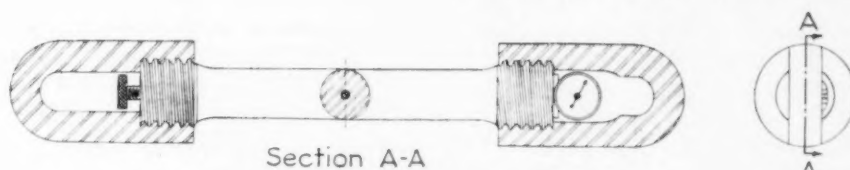


Fig. 1.—Assembly of Proving Bar with Shackles in Section.

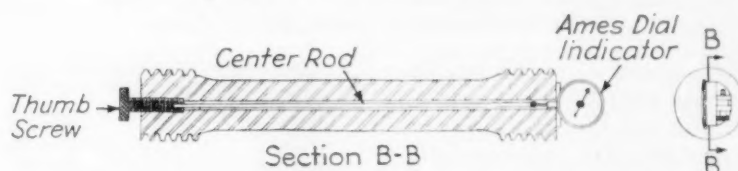


Fig. 2.—Longitudinal Section Showing Center Rod Attached to Thumb Screw for Zero Setting of Dial Indicator at Opposite End.

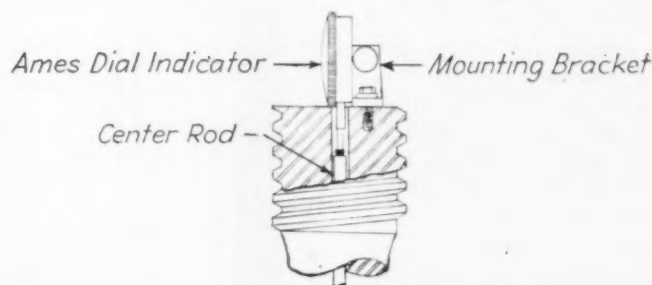


Fig. 3.—Partial Section Showing Dial Indicator Mounted at One End of Proving Bar and Center Rod in Contact with Indicator Plunger.

pared with measurements made along the surface. For example, a single axis reading automatically gives an average of all the elastic movements involved. A bar affording a capacity of 500,000 lb. was chosen for the initial manufacture.

The purpose of the present paper is merely to describe the newly designed proving bar as a matter of possible general interest to users of testing machines.

## DESIGN

Figure 1 shows the new proving bar with associated measuring apparatus and shackles for tensile load-

and attached to the rod provides a convenient means for zero adjustment. The proving bar was machined from a 4½-in. diameter rolled S.A.E. 4340 alloy steel bar of high elastic quality. Heat treatment consisted of quenching in oil from 1575 F. followed by drawing to 1200 F. These operations were conducted before machining in order to obtain a maximum degree of straightness and to avoid warpage sometimes accompanying heat treatment.

A dial indicator, reading to 0.0001 in., is mounted at the opposite end of the bar with its spindle in contact with the free end of the actuating

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

<sup>1</sup> The opinions expressed herein are the authors' and not necessarily those of the Navy Department.

<sup>2</sup> Principal Materials Engineer and Assistant Materials Engineer, respectively, Boston Naval Shipyard, Boston, Mass.

<sup>3</sup> I. H. Cowdrey and R. G. Adams, "Materials Testing," John Wiley and Sons, Inc., New York, N. Y., p. 116 (1935).

<sup>4</sup> Standard Methods of Verification of Testing Machines (E 4 - 36), 1944 Book of A.S.T.M. Standards, Part I, p. 957; Part II, p. 1157; Part III, p. 1059.

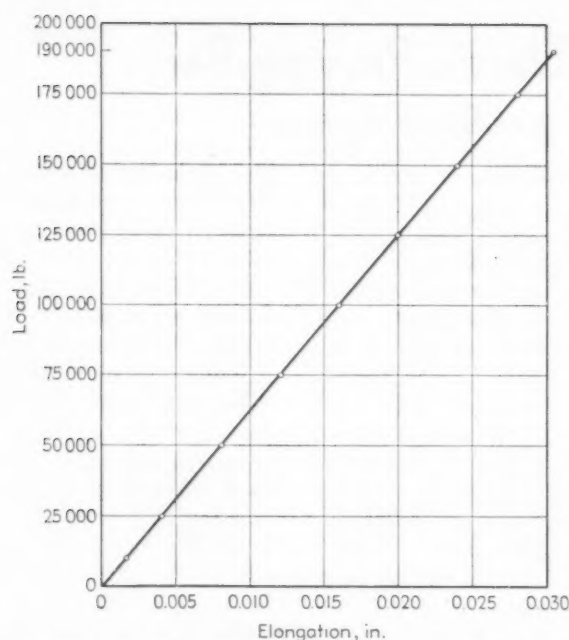


Fig. 4.—Calibration Curve for Elastic Proving Bar up to 190,000 lb. Obtained in a 200,000-lb. Baldwin-Southwark Testing Machine.

rod (Figs. 2 and 3). The tension spring controlling the rack gear of the indicator mechanism causes the spindle to follow the movements of the actuating rod.

In operation, the center rod remains unchanged in length while the proving bar gains length under the load. The relative movement taking place is indicated on the dial. Movements amounting to about 40 divisions on the indicator may be obtained for each 25,000-lb. load increment on the bar. On this basis, one division on the dial is equivalent to approximately 625 lb. This sensitivity amounts to approximately one fifth of one per cent per full division when the bar is loaded to 300,000 lb. This, however, is not necessarily the limit of sensitivity, since a more refined indicating device could be employed.

#### PRELIMINARY CALIBRATION

For purpose of preliminary information only, the bar was calibrated in a 200,000-lb. Baldwin-Southwark testing machine which had recently been verified and found to be accurate within 0.75 per cent of indicated load against a Navy standard proving ring. The resulting calibration curve for the proving bar is shown in Fig. 4 and was obtained with the bar positioned vertically in the machine as shown in Fig. 5. The satisfactory straight-

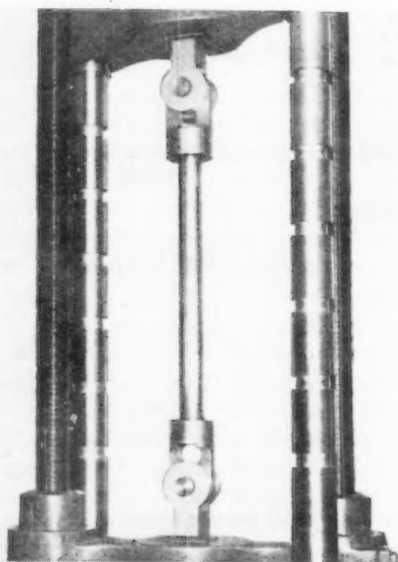


Fig. 5.—Elastic Proving Bar Shown in 200,000-lb. Baldwin-Southwark Testing Machine.

line relationship between load and elongation should be noted. In this connection, the calibration points were reproduced with ease in successive runs as closely as could be read from the dial gage and the testing machine pointer. Data for the calibration curve were obtained from eight runs,<sup>5</sup> and care was taken at all times to observe temperature uniformity.

#### CONCLUSION

In view of the promising results obtained in the above preliminary

<sup>5</sup> See footnote 4, pp. 958, 1158, and 1060, respectively.

calibration, it appears desirable that the proving bar now be calibrated against loads known to be accurate within 0.1 per cent, in accordance with A.S.T.M. requirements for elastic calibrating devices.<sup>4</sup> In this connection, it is planned to request the National Bureau of Standards to calibrate the bar to 500,000 lb. in order to have full use of the bar's capacity. This figure is apparently within reach as the bar has already satisfactorily withstood a proof test load of 510,000 lb. with no permanent deformation indicated by the dial. This seems to be a rather satisfactory showing for a small bar. It suggests also that proving bars of 1,000,000-lb. capacity or more could be easily manufactured on this principle. It can be mentioned also that this principle could be employed in proving bars designed for use in compression, due regard being given to slenderness ratio.

#### DISCUSSION

MR. H. F. MOORE.<sup>1</sup>—This paper presents an ingenious simplification of an elastic calibrating device consisting of a tension bar of steel. It probably could be modified to serve as a compression bar as well. In common with other tension and compression bars now in use it has the advantage of relatively light weight and, presumably, of low cost. It has the disadvantage of relatively low sensitivity as compared with the proving ring now in rather wide use. It is to be hoped that the suggestion of the authors that the sensitivity and reliability of the stretch-measuring equipment will be increased beyond that feasible with a clock-work type micrometer dial. This is not a criticism of that type of dial for general use, but its use for measuring stretches down to 0.00002 in. is of doubtful reliability.

Although the particular tension bar described by the authors would hardly be acceptable by A.S.T.M. standards, except possibly for maximum load, improvements in the sensitivity and accuracy of its stretch-measuring apparatus might make it much more useful.

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# Progress in Work on Ultimate Consumer Goods

## Forms for Consumer Standards Developed

*Editor's Note.*—This article, prepared by Professor H. J. Ball as Chairman of the Committee on Ultimate Consumer Goods, will be of great interest to the members of the Society as setting forth the start that is being made in this important field.

**T**HIS article is prepared especially to keep the members of the Society informed of the progress of the work and plans of the Administrative Committee on Ultimate Consumer Goods, and is based upon the annual report which the Administrative Committee recently submitted to the Executive Committee. For those interested in background material, reference should be made to the March, 1945, issue of the ASTM BULLETIN, in which announcement was made of the decision of the Executive Committee to extend the standardization activities of the Society in the field of ultimate consumer goods, together with the story of the preliminary study and recommendations upon which the decision was based. The personnel of the Administrative Committee is given in an article in the May, 1945, issue of the BULLETIN.

The scope of the Committee's work, as established by the Executive Committee, is as follows:

The committee has for its function the supervision of the Society's activities in the development of standards for ultimate consumer goods that permit of definitions, test data, or test limitations that can be measured by engineering methods, but not including assemblies except where evaluation of materials or workmanship is concerned.

This clearly indicates the intention to base the Society's standardization work in this field of ultimate consumer goods upon sound engineering principles and practices as it has done so successfully heretofore in the field of industrial goods.

Whenever a term, such as "ultimate consumer goods," may have somewhat different implications to various individuals, it is a primary requisite that it shall be defined as clearly as possible. For this purpose the Administrative Committee

has adopted the following as a guide in its deliberations:

*Ultimate Consumer Goods* are materials or products which in the "as is" condition are intended for sale to an individual purchaser for his personal property or use, and not for fabrication for resale. Such an individual is the *Ultimate Consumer*.

Since the definition places its emphasis on the end-user of an article, it is also helpful in directing the thinking when the same articles may be used both as industrial goods and as consumer goods.

In the development of standards for ultimate consumer goods, the Administrative Committee gave early thought to the direction along which the work of the Society should proceed in order best to serve industry and the ultimate consumer. As a general policy the committee, therefore, plans to lay primary emphasis on the development of methods of test for use values of ultimate consumer goods. The development of specifications for such goods will be undertaken only when it appears that adequate methods of evaluation are available and that there is a demonstrated need for such specifications.

The Administrative Committee has given considerable time and thought to the form and content which standards pertaining to ultimate consumer goods should have. It has prepared the accompanying Method of Test Form and Specification Form, which embody all pertinent ideas to date. They have been circulated to the officers of all standing committees of the Society for comment and criticism, and suggestions coming from any source will be welcomed by the Administrative Committee.

Attention is directed to some of the features wherein these Forms differ from the usual A.S.T.M. standard:

*Title.*—The title should be clear-cut and name the specific end-use for which the standard has been written whenever practical. The phrase "applicable to ultimate consumer goods" will appear in each title, and the A.S.T.M. numerical designation will be preceded by CG.

*Preamble.*—The second and third paragraphs are new. The former disclaims responsibility of the A.S.T.M. for any representation based on the standard and places it upon the party who makes the claim. The third paragraph warns the user of the standard that the presently available data upon which the standard has been based may not cover adequately every use value of the method or article, and that appropriate revisions may be expected as new data and experience become available.

*Scope.*—Since the title of a standard must by its nature be brief, it is expected that the scope clause shall contain a complete amplification of the intent indicated by the title. Emphasis is laid upon the formulation of a clear, precise, and definite statement of the applicability and limitations of the coverage of the standard, and its end-uses should be explicitly stated. No doubt should be left in the mind of the user of the standard as to the exact use for which only it is intended.

*Definitions or Description of Terms.*—Here the fundamental premise is that the terminology used shall be clear to the ultimate consumer and this may present a new problem. Its solution will require such care and choice of phrasing that the use characteristics in which the consumer is interested may be understandably interpreted from the results of the test procedures.

*Requirements, Test Procedures.*—The establishment of chemical and physical requirements of an article presumes the availability of sound test methods for suitably measuring those properties. It is envisioned that present standard methods of test will be utilized, provided they

## SUGGESTED TEST METHOD FORM

*Standard Method of Test for*TITLE [INCLUDE NAME OF ITEM AND POTENTIAL USE]<sup>1</sup>APPLICABLE TO ULTIMATE CONSUMER GOODS<sup>2</sup>

A.S.T.M. Designation: CG 999 - 4-

ADOPTED, 19--; REVISED, 19--.<sup>3</sup>

This Standard of the American Society for Testing Materials is issued under the fixed designation CG 999; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The American Society for Testing Materials has adopted this standard under a procedure which, in its opinion, is competent, unbiased, and authoritative. Any representations based on this standard such as labeling, certification and advertising, are the responsibility of the party making the claim and not of A.S.T.M.

While this standard has been developed with consideration of properties on which data or use values are available, it must be recognized that this standard may not cover adequately all use values, and is therefore subject to revision as experience may show to be required.

**Scope**

Under the scope clause the information in the title should first be repeated and the prospective end uses which the method of test is designed to cover should be clearly

<sup>1</sup> Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee XYZ. (Designate the specific committee having jurisdiction. When a committee has a section or subcommittee dealing specifically with Consumer Goods the said section shall also be named.)

<sup>2</sup> Ultimate Consumer Goods are defined as materials or products which in the "as is" condition are intended for sale to an individual purchaser for his personal property or use and not for fabrication for resale. Such an individual is the Ultimate Consumer.

<sup>3</sup> Prior to adoption as standard, this method of test was published as tentative in 19--., being revised in 19--.

defined. For example: "Wear test for pile fabrics used in upholstery" —not "Wear test for pile fabrics." Also—"Freezing point of anti-freeze compounds for use in auto cooling systems" rather than "Freezing point of anti-freeze compounds."

**Significance of Tests**

The significance, limitations, and applicability of the tests should be clearly stated with respect to use values of the material.

**Definitions or Descriptions of Terms**  
Considerable attention must be

devoted to the matter of terminology in standards for ultimate consumer goods. The actual test work normally will not be performed by the ultimate consumer but by manufacturers — distributors — and commercial laboratories who specialize in the evaluation of ultimate consumer goods. In order for these organizations to inform the ultimate consumer as to the use characteristics of an item, simple consumer terminology must be coordinated with standard methods of test.

**Test Specimens or Samples**

Care must be exercised in the specification of test specimens or samples to insure adequate consideration for the shape or design of the finished commodity in which the material is to be used. For example: Tests on glazed earthenware to be used in dinnerware must be conducted on samples which closely approximate in shape the finished commodity.

**Procedures**

Procedures should be developed

from the standpoint of the conditions and stresses surrounding ultimate consumer goods as they are used by the ultimate consumer. Testing apparatus, reagents, etc., should be devised or adapted to approximate closely such conditions of use. It is recommended that detailed requirements for apparatus, unless quite brief, be placed in a separate section.

It may be necessary to specify tests on partial or complete assemblies in order to evaluate the potential use value of the material.

**Units of Measurements**

Units of measurements which are to be passed on to the ultimate consumer should be expressed in terms of the inch-pound and Fahrenheit systems because of the lack of familiarity with the metric and Centigrade systems in a large part of the consuming public.

**Report**

The committee should state what it considers to be the essential data to be reported.



*Standard Specifications for*TITLE [BRIEF BUT CLEAR CUT AND INCLUDING USE WHEN PRACTICAL]<sup>1</sup>APPLICABLE TO ULTIMATE CONSUMER GOODS<sup>2</sup>

A.S.T.M. Designation: CG 998 - 4-

ADOPTED, 19--; REVISED, 19--.<sup>3</sup>

This Standard of the American Society for Testing Materials is issued under the fixed designation CG 998; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The American Society for Testing Materials has adopted these specifications under a procedure which, in its opinion, is competent, unbiased, and authoritative. **Any representations based on these specifications such as labeling, certification and advertising, are the responsibility of the party making the claim and not of A.S.T.M.**

While these specifications have been developed with consideration of properties on which data or use values are available, it must be recognized that these specifications may not cover adequately all use values, and are therefore subject to revision as experience may show to be required.

**Scope**

Under the scope clause the information in the title of the specifications should first be repeated and any amplification made when necessary. Following this it is particularly important to define clearly the

applicability and limitations of the specifications. In this connection it will be important to state explicitly the end uses of the material covered by the specifications. For example, "Soap for Laundering Cotton and Linen Only," rather than "Soap for Laundering." Also, "Pipe ordered under these specifications is intended for the usual home low-pressure steam and hot water heating systems and for the usual domestic distribution of water, oil, and gas," rather than "Pipe ordered under these specifications is intended for ordinary uses in steam, water, gas, and air lines."

<sup>1</sup> Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee XYZ. (Designate the specific committee having jurisdiction. When a committee has a section or subcommittee dealing specifically with Consumer Goods the said section shall also be named.)

<sup>2</sup> Ultimate Consumer Goods are defined as materials or products which in the "as is" condition are intended for sale to an individual purchaser for his personal property or use and not for fabrication for resale. Such an individual is the Ultimate Consumer.

<sup>3</sup> Prior to adoption as standard, these specifications were published as tentative in 19--, being revised in 19--.

**Definitions or Descriptions of Terms**

Under this section definitions or descriptions of terms shall be included when necessary and they shall be so phrased as to be explicit to the ultimate consumer.

**Requirements**

There may be included in the specifications various requirements, both chemical and physical, involving chemical and physical tests. These requirements will usually be determined by methods of tests of the A.S.T.M. specifically referred to. It will be essential that any such requirements will be followed by an explanation of the significance of the said test, expressed in use values of the material in order that the ultimate consumer may have some conception of the importance of the requirements in relation to his use of the material.

**Shape, Size, Dimensions and Other General Clauses**

These clauses should be handled with great care. Generally speaking, standard sizes, dimensions or other such features shall only be embodied in the specifications when there has already been established through proper standardizing bodies, a practice which is recognized as justifying dimensional or other universal commercial practice.

**Claims**

Any representation that the material complies with the requirements of the specifications, including labeling, certification, and ad-

vertising, is a responsibility entirely of the party making such representation. It is recognized that such parties can make only such representation based on random sampling and testing of the material. The degree of sampling and the extent of testing necessary to protect the ultimate consumer depends upon the production control methods of the supplier and the character of the material. It also depends upon the cost of the material as, generally speaking, even where safety or other vital features may be involved, the relation of cost of sampling and testing to the cost of the material or product is important as this cost is included in what the ultimate consumer pays for the material. It may be generally stated that if the cost of sampling and testing is in excess of one half of one per cent of the cost of the material, the sampling and testing procedure as well as the requirements of the specifications should be carefully reviewed.

**Ultimate Consumer Acceptance**

In view of the above, the ultimate consumer must recognize that any item he buys under these specifications is acceptable providing it conforms substantially, if not exactly, to the requirements of the specifications. Any claims for replacement should be made upon the party who represents the material as complying with the specifications. In the event of unsatisfied claims on any material manifestly inconsistent with the requirements of the specifications, he has recourse to the Federal Trade Commission through appropriate channels.

will correctly interpret the conditions of consumer use. It is anticipated, however, that methods of test designed primarily for industrial use may often be found inappropriate when applied to ultimate consumer goods, and that considerable thought must be given to the development of new methods which will evaluate the end-use requirements of importance to the ultimate consumer. To assist in his understanding of the standards for ultimate consumer goods it is recommended that English units be employed rather than metric.

*Claims, Ultimate Consumer Acceptance.*—It is expected that the ultimate consumer will be advised that any article purchased under a specification is considered acceptable provided it conforms substantially to the stated requirements, that representations that the item does so comply are the responsibility of the party making them, that claims

for replacement of nonconforming merchandise should be made to such party, and that in the event of unsatisfied claims recourse may be had to the Federal Trade Commission through appropriate channels.

The question of how work on standards for ultimate consumer goods might be handled within a standing committee poses a problem which has been given considerable attention by the Administrative Committee. The question arises because of the desirability of having a reasonable balance of interests between producers and ultimate consumers when work on consumer goods standards is undertaken. Those now classified as consumers on standing committees are very generally representative of the industrial consumers, and may or may not be qualified to serve as representatives of the ultimate consumer. In any event, the Administrative Committee has agreed that

A.S.T.M. standards on consumer goods will not carry proper weight, if in their establishment there has not been competent representation from such groups as the national women's clubs, American Home Economics Assn., departments of home economics in the colleges and government bureaus, consumer co-operatives, labor organizations, retail, mail order and department stores, magazine publishers, etc.

At the present writing, the Administrative Committee believes it has evolved a procedure which will be applicable to the conditions in all standing committees which may have to deal with consumer goods. This will be announced at a later date after it has had opportunity to study the procedure critically from every angle, and to determine what changes may be necessary in the Society's Regulations Governing Technical Committees.

## Discussion of Paper on Effect of Repeated Loading on Bond Strength of Concrete<sup>1</sup>

MR. C. P. SISS<sup>2</sup> (*by letter*).—Although a great many investigations have been made of the properties of plain and reinforced concrete subjected to repeated loading, our knowledge of this subject is far from complete. This paper is an important contribution to that knowledge, and it is hoped that Mr. Muhlenbruch will continue his activities in this field.

The author refers to Figs. 15 and 16 as "stress-cycle diagrams." This designation may be misleading since the stress plotted on these diagrams is not that which produced failure at the corresponding number of cycles, but rather a stress which might be considered a measure of damage to the static bond strength. These curves might more properly be called "damage-cycle diagrams." They can be interpreted as representing the damage to static bond strength at any stage in a repeated-load test under a given stress. Each curve on Fig. 15 or 16 can be considered as

representing the damage history of a single specimen, although several companion specimens are required to plot such a curve since the damage can be assessed only by means of a destructive test.

The fact that the curves in Figs. 15 and 16 show no tendency to flatten out presents considerable food for thought. It seems entirely possible that failure in repeated loading might have been produced if the tests had been carried to a sufficiently large number of cycles, even for those tests in which the repeated load was less than 25 per cent of the static ultimate. At first thought, this possibility is startling since practically all previous work on fatigue of concrete has indicated an endurance limit in the neighborhood of 50 per cent of the ultimate static strength. Moreover, the endurance limit has usually been found at less than 500,000 cycles. In the Illinois investigation,<sup>3</sup> in which many of the tests were carried beyond 4,000,000 cycles, no failures in fatigue were obtained at more than 600,000 cycles.

It is probable, however, that the

difference in behavior of these bond specimens lies in the nonuniform distribution of bond stress along the bar. The damage produced in a repeated-load test is proportional to the maximum bond stress rather than to the average bond stress. Although the average bond stress in the repeated load tests may have been only 25 per cent of the ultimate bond stress in a static test, the maximum was undoubtedly much greater. As the damage occurs, the bond resistance in the damaged area is decreased, and the point of maximum stress shifts along the bar. Thus, damage is progressive and tends to increase as the number of cycles increases. It is, of course, possible that no more damage would occur once it had progressed far enough along the bar to lower the maximum stress below some limit. The proper condition for such cessation of damage would appear to depend not only on the magnitude of average stress in the repeated-load test but also on the length of embedment.

The length of embedment would also appear to have a significant effect on the amount of damage suffered at any given number of cycles. The increased average stress at fail-

<sup>1</sup> C. W. Muhlenbruch, "The Effect of Repeated Loading on the Bond Strength of Concrete," *Proceedings, Am. Soc. Testing Mats.*, Vol. 45, p. 824 (1945).

<sup>2</sup> Special Research Assistant Professor of Theoretical and Applied Mechanics, College of Engineering, University of Illinois, Urbana, Ill.

<sup>3</sup> Fatigue of Concrete, Engineering Report No. 34-1, Bureau of Materials, Illinois Division of Highways, March, 1934.



ure for the specimens with shorter lengths of embedment is usually considered to result from a difference in distribution of stress rather than from any increase in maximum stress. That is, the ratio of maximum to average stress at failure is smaller for short lengths of embedment. It does not seem likely that this difference in the ratio of maximum to average stress would exist also at loads less than those producing failure, such as those used in the repeated-load tests. It is more probable that the ratios at those loads would be nearly equal for all lengths of embedment. If, then, specimens with various lengths of embedment are tested in repeated loading at equal percentages of the average stress at failure in static tests, the average, and thus the maximum stress, would be greater for bars with shorter lengths of embedment.

Reference is made to the accompanying Table I in which the reduction in static bond stress at various amounts of slip and at the maximum load are compared for the various lengths of embedment. These data seem to indicate an increase in damage with decrease in length of embedment, which is in agreement with the author's conclusion. However, as the author has pointed out, the load was greater for the 6.25-in. embedment than for the 8- or 10-in. embedment, and was even greater for the 5-in. embedment.

In the accompanying Table II, the reductions listed in the previous table have been expressed in percentage of the static bond stress for the virgin specimen at corresponding values of slip. One thing is immediately apparent: the percentage reduction of stress at maximum load shows a trend just the reverse of that at a specified amount of slip. Furthermore, for the two shortest lengths of embedment, the amount of damage in per cent decreases as the specified slip increases and is

TABLE I.

| Length of Embedment, in. | Load on Specimen, per cent of static load <sup>a</sup> | Reduction in Static Bond Stress, psi. |                     |                     |                 |
|--------------------------|--|---------------------------------------|---------------------|---------------------|-----------------|
|                          |  | At slip of 0.001 in.                  | At slip of 0.01 in. | At slip of 0.05 in. | At maximum load |
| 5.....                   | 37.2   | 490                                   | 465                 | 500                 | 210             |
| 6¼.....                  | 33.5   | 280                                   | 285                 | 130                 | 200             |
| 8.....                   | 23.6   | 0                                     | 110                 | 160                 | 220             |
| 10.....                  | 23.2   | 58                                    | 95                  | 160                 | 180             |

<sup>a</sup> Number of cycles is maximum in author's Table IV.

least for the maximum load, while just the opposite is true for the remaining specimens. Although the reason for this is not clear, it would appear that the nature of the damage under repeated loading is affected by the length of embedment of the bar. Since the 5-in. length of embedment (8 diameters) finally used in these tests is rather small, it is hoped that further studies of this variable will be made.

From a study of Figs. 11 to 14 it would seem that the loads applied in the repeated-load test for all lengths except 10 in. were sufficient to produce slip at the free end of the bar. It would be of interest to know whether any measurements were made of this slip during the repeated load tests, since, on the basis of results obtained by Abrams,<sup>4</sup> such slip should increase during the test. The writer believes that observations of free-end slip and also of loaded-end slip, if possible, would be of considerable help in understanding the mechanism of failure. If measurements of slip at the loaded end are not feasible in the repeated-load tests, it would probably be worth while to make such measurements in the static tests, both on the virgin specimens and on the damaged specimens.

It is of interest to speculate on the nature of the damage to the bond. In pull-out tests of deformed bars, the adhesion must be overcome before the lugs or deformations come into action. After that, the breakdown of bond is either by crushing of the concrete in compression or by failure of the concrete in shear. It is also generally considered that considerable slippage must occur after the adhesion is destroyed before the lugs can come into play. For a short length of embedment and with loads comparable to those used in these tests, it is probable that the adhesion was destroyed along the entire length of the bar. For a long length of embedment, there might still have been some adhesion near the free end of the bar at the beginning of the repeated-load test. This would be indicated by the absence of slip at that end at the load used in the test. This adhesion may

<sup>4</sup> D. A. Abrams, "Tests of Bond Between Concrete and Steel," University of Illinois Engineering Experiment Station, *Bulletin* 71, 1913, see Fig. 39, p. 102.

TABLE II.

| Length of Embedment, in. | Load on Specimen, per cent of static load | Reduction in Static Bond Stress, per cent of stress for virgin specimen |                     |                     |                 |
|--------------------------|---|---|---------------------|---------------------|-----------------|
|                          |   | At slip of 0.001 in.  | At slip of 0.01 in. | At slip of 0.05 in. | At maximum load |
| 5.....                   | 37.2                                      | 55.7  | 30.7                | 29.0                | 11.9            |
| 6¼.....                  | 33.5                                      | 36.0  | 20.4                | 11.4                | 8.5             |
| 8.....                   | 23.6                                      | 0.0   | 9.2                 | 12.7                | 16.4            |
| 10.....                  | 23.2                                      | 9.0   | 10.5                | 14.4                | 16.0            |

eventually be destroyed after a sufficient number of cycles, or it may remain indefinitely. (The answer to this can be obtained by slip measurements in the repeated-load test.) Near the loaded end, the lugs are almost certain to be in bearing, and damage in this region would consist of crushing of the concrete or of shearing failure.

Both failure of the adhesion and local crushing of the concrete in front of the lugs would cause a decrease in the load required to produce a given amount of slip. For the longer embedments, the possibility that the adhesion was not destroyed for the full length of the bar might serve to explain the smaller reductions in load at small slips for those specimens. The lower average bond stresses at maximum load which are found in static tests for bars of longer embedments are the result of progressive failure and the consequent inability to mobilize the maximum bond resistance simultaneously at all points along the bar. It seems reasonable that crushing of the concrete at the loaded end of the bar during the repeated-load test would have the effect of aggravating this condition and thereby producing damage to the maximum bond strength in a subsequent static test.

It is obvious that bond strength in repeated loading is a function not only of length of embedment but also of concrete strength, type of lug, and other variables which are known to affect the static bond strength. The question which must be answered, however, is whether these variables affect the repeated-load bond strength in the same manner as they affect the static bond strength. If the damage to bond resistance is due to a more or less localized maximum stress, and if this damage is progressive, the answer to the above question must be no. If so, it is unfortunate, since the determination of the effect of repeated-

loading on bond resistance is made much more difficult because of the many additional variables which must be considered.

There is no statement in this paper regarding the magnitude of the minimum stress in the repeated-load tests. The writer has made some rough calculations which indicate it to be in the range of 6 to 12 per cent of the maximum stress. The three quantities needed to describe completely a repeated-load test are (1) the maximum stress applied, (2) the range of stress, and (3) the number of cycles. In choosing the values of these variables, consideration must be given to the service conditions of concrete structures, as well as to the ever-present limitations of time and equipment.

For most reinforced-concrete structures, the minimum stress is that produced by dead load. The superposed repeated stress is due to live load, and is in most cases the result of moving loads. For this condition, the ratio of minimum to maximum stress will depend on the ratio of dead to live load and will usually be fairly high. There are, of course, also structures subject to complete reversal of stress. For example, Slater *et al.*<sup>5</sup> state that a ship at sea may undergo 10 to 15 reversals of stress per minute. There can be little question that further work is needed on the effect of range of stress as a variable in

tests of concrete under repeated load. An additional complication which will be introduced is that of creep or plastic flow resulting from the constantly applied minimum load. The problem of creep at the maximum load is also of considerable interest.

From a practical point of view it would appear that the author has carried his tests to an excessively large number of cycles, since there are relatively few reinforced-concrete structures (except, perhaps, the ships mentioned above) which would ever be subjected to over 4,000,000 cycles of loading. However, from the standpoint of fundamental studies of repeated-load bond strength, it would have been desirable to apply even more cycles of loading. If an endurance limit exists, only sufficient repetitions to establish that limit are required. However, where there appears to be no endurance limit, or where it occurs at an excessively large number of cycles, the investigation may be restricted to a range of cycles commensurate with the possible service conditions. The author's procedure of obtaining data for "damage-cycle" diagrams is an excellent means of handling such a situation and may prove to be a useful concept in other fields of fatigue testing.

MR. C. W. MUHLENBRUCH (*author's closure by letter*).—The suggestion of the nomenclature "damage-cycle diagrams" rather than "stress-cycle diagrams" as used in the paper is readily acceptable to the author.

The repeated loading machine is now being partially rebuilt to permit

the application of greater maximum load. This higher capacity apparatus will permit the study of longer embedment lengths and also the rate at which the point of maximum stress moves along the bar. This latter consideration will be investigated by the use of a larger but hollow (drilled-out) reinforcing bar with SR-4 strain gages along the center cavity of the bar. This type of specimen will also permit a study of the distribution of the bond stresses while load is being applied to the specimen. A further variable is the rate of application of load.

The slip at the loaded and free ends of the bar was not measured during repeated loading. An attempt is now being made, by increasing the length of projection of the reinforcing bar on the loaded end and placing the specimen on a "stool," to measure the slip at both the loaded and unloaded ends. This type of specimen will permit slip measurements during both repeated and static loading.

On page 837 the minimum load on all specimens is stated to be 513 lb. This load is from 5 to 10 per cent of the maximum stress. In this exploratory phase of the investigation an attempt was made to keep the minimum load as small as possible to permit a maximum range of stress and therefore the greatest damage. In subsequent tests the range of stress will be investigated and some specimens will be subjected to a sufficient number of cycles to cause complete failure due to repeated loading.

<sup>5</sup> W. A. Slater, G. A. Smith, H. P. Mueller, "Effect of Repeated Reversals of Stress on Double-Reinforced Concrete Beams," *Technologic Paper No. 102*, U. S. Bureau of Standards (1921).

## Discussion of Paper on Corrosion Criteria—Their Visual Evaluation\*

MR. F. L. LAQUE<sup>1</sup> (*by letter*).—Mr. Darrin's paper represents a welcome step toward a more orderly

description of the corrosion of test specimens beyond what can be indicated by data on weight loss, changes in mechanical properties, or other alterations that can be measured quantitatively and described numerically.

In this connection, it should be noted that something along the same line is receiving attention by the American Coordinating Committee on Corrosion through a Subcommittee on Standard Terms and Symbols. The organization of this

\* Marc Darrin, "Corrosion Criteria—Their Visual Evaluation," *ASTM BULLETIN*, No. 138 January, 1946, p. 37.

<sup>1</sup> In charge of Corrosion Engineering Section, Development and Research Div., International Nickel Co., Inc., New York, N. Y.



subcommittee stemmed, in part, from methods for the examination of corroded metal proposed by F. A. Champion<sup>2</sup>—referred to by Mr. Darrin in his paper—and in part from somewhat similar systems of classification being used in some corrosion laboratories in this country. Mr. Darrin's proposals will, no doubt, be of interest to this committee in working out a generally applicable scheme that will provide adequately for such special types of corrosion investigation as the one for which Mr. Darrin developed his rating system.

Mr. Champion proposed numerical definitions of descriptive adjectives, such as few, small, severe, etc., as applied to the number, size, and intensity of forms of local attack in much the same way that Mr. Darrin defined terms related to depth of attack. Champion also provided supplementary charts to illustrate graphically the terms for type, number, size, and intensity of attack which would seem to be a useful part of any scheme of classification.

It seems desirable to draw attention to the fact that the proposed terms for describing depths of pits, and particularly their relation to each other, are significant only with respect to specimens exposed for the same length of time. It would not be proper to assume that a "deep" pit (0.015 to 0.030 in.) that developed in a 10-day test had the same significance as a similar "deep" pit that developed to the same depth during exposure of a specimen for ten years. For this reason, the writer is inclined to question the desirability of using descriptive adjectives instead of simply stating the depth of pits which have to be measured, or estimated anyway, before the adjectives may be used properly according to Mr. Darrin's Table I.

In view of the distorted relationships among exposed area of specimen, volume of solution, and time of contact that may exist in laboratory tests as compared with actual practice, one is inclined to question the assignment of numerical values to the different conditions of the testing liquid after test (section C of

Form 1), or at least the combination of these relatively uncertain values with the more precise descriptions of the test specimens in arriving at a numerical measure of the over-all desirability of a particular system.

In conclusion, the writer wishes to emphasize his hope that this contribution by Mr. Darrin will excite further interest in the development of more or less standardized terms and symbols for the description of corrosion of test specimens. It seems likely that the subcommittee of the American Coordinating Committee on Corrosion mentioned previously will welcome the assistance of Mr. Darrin and others active in the work of A.S.T.M. corrosion committees in arriving at a system of classification that will be generally applicable and which eventually may be included in A.S.T.M. procedures for carrying out corrosion tests.

MR. MARC DARRIN (*author's reply by letter*).—An important purpose of this discussion is to invite helpful comments such as Mr. LaQue's. Although we are in general agreement there are some differences of opinion with respect to detail, which we shall endeavor to clarify.

There is no objection to recording the precise depth of pits (which is ordinarily done for purpose of checking), but it has been our experience that there is no significant difference in corrosion resistance within the ranges given in Table I. Since these ranges often may be judged by the eye, and since their use simplifies recapitulation of data and exchange of pertinent information, it is frequently advantageous to employ them.

Regarding time of exposure, this method provides for comparisons only between panels exposed for the same period of time, which should be noted on the first line of Form 1. How long an exposure should be is beyond the scope of this discussion; however, we have tried many periods from a few hours to over six years, and have not found any metallic system which failed to indicate its true trend within six months in an aqueous medium. It may be that this does not apply to atmospheric corrosion or to panels with organic coatings.

Mr. LaQue questions the inclusion of values for the different conditions of the testing liquid after the test. As we have pointed out, these criteria, and many others, may be omitted if they are of no importance for the application under consideration. For example, the condition of the liquid is of no importance in the selection of metals of construction for a once-through heat exchanger. In this case the deciding factor is the increased life which could be reasonably expected if the tubes, tube-plates, or shell are made of a very corrosion-resistant metal such as nickel, chromium-nickel steel or monel. On the other hand, it is important to know the condition of the liquid when selecting the proper treatment of the water in an existing recirculating system, especially if corrosion products might clog spray nozzles or other narrow passages. This is commonly the case with all manner of cooling towers which are employed for air conditioning, engine jacket cooling, condensers, and the like. In these cases the condition of the water cannot be disregarded. More specific illustrations are: to determine whether the best maintained concentration of a corrosion inhibitor, such as sodium chromate, is 500 or 100 ppm. for a particular system; to compare the relative effectiveness of chromate, bichromate, nitrite, and organic inhibitors; to determine whether it is permissible to decrease the concentration of inhibitor in a particular refrigeration brine, say from 100 to 50 lb. of bichromate per 1000 cu. ft.; to determine how much the concentration of chromate or other inhibitor has to be increased as the chloride content of natural waters increases; and, the effect of concentration of mineral salts in evaporative coolers, variations in pH, temperature, and aeration. Obviously there are many special corrosion tests where the final effect on the corroding medium may be disregarded: for example, the determination of the effectiveness of chromic acid anodic treatments; cathodic protection of aluminum as by the alclad process; bichromate treatments for zinc plate, magnesium alloys and other metals; and the comparison of corrosion inhibitive pigments such as zinc chromate and basic lead chromate.

<sup>2</sup> F. A. Champion, "New Methods for the Examination of Corroded Metal," *Journal, Inst. Metals* (London), Vol. 69, pp. 47-66 (1943).

In general it will be found in practice that most of the troublesome difficulties encountered in comparing corroded panels may be eliminated by following the outlined procedure. Of course, no system of scoring can dispense with the necessity of applying judgment to the proper weighting of the scores if they are to be used as a basis for selection of materials or treatments for a particular problem; however, the personal factor is almost eliminated in obtaining the data outlined, and these data are sufficiently complete for an experienced engineer readily to evaluate them for most specific purposes.

MR. F. A. CHAMPION<sup>2</sup> (by letter).—I have read with interest Mr. Darrin's paper in the January, 1946, issue of the ASTM BULLETIN on "Corrosion Criteria—Their Visual Evaluation," and wholeheartedly agree with him on the desirability of establishing uniform nomenclature for different types of corrosion.

In referring to my paper<sup>3</sup> on the subject, Mr. Darrin has raised some criticisms of my method, and I should be glad of the opportunity to comment on these criticisms and correct an error.

I would first make it clear that my paper was divided into two parts, the first dealing with the qualitative method of assessment to which Mr. Darrin refers, and which depends solely on examination by the unaided eye or with the aid of binocular and monocular microscopes, while the second briefly describes an entirely distinct quantitative method of assessment of corrosion, depending on radiography, which is in course of development. The description of both methods in the same paper may have been a little confusing, but I hoped to show that if the radiographic method can be successfully developed, it will provide a valuable complementary method to the more qualitative method of macroscopic and microscopic examination.

I am not surprised that my method should appear to be complicated, but I am sure that a very

little practice would show that it is not so. The use of charts for comparison with the corroded specimen is very valuable in improving the accuracy and reliability of the observations, with the result that the seven stages given in my paper are found in practice to be more than justified. In fact, it is quite often necessary to subdivide these stages by the use of the fraction ( $\frac{1}{2}$ ), although this cannot readily be translated into words.

I feel very dubious of the value of a general scoring system such as that given in Table II of Mr. Darrin's paper, since the importance of different types of corrosion varies with the application of the metal to be considered. I have described<sup>4</sup> the calculation, from the observations by my method of examination, of a "perforation factor" for indicating the danger of perforation by corrosion. I suggest that the calculation of such special factors from general observations by a standardized system is a more satisfactory procedure than an attempt to evaluate a single score for all purposes.

No doubt the system I have suggested, and which was developed for work on light alloys, would need considerable modification before it would be acceptable for all fields of investigation of corrosion. I feel, however, that the important feature of charts for comparison with flexible yet accurate and concise descriptions of the attack should be retained if at all possible.

MR. DARRIN (author's reply by letter).—Our comments regarding Mr. Champion's report are intended to draw attention to his important contribution, particularly his drawings which illustrate different types of corrosion. It would be helpful if these or similar drawings were given wider dissemination by publication in the ASTM BULLETIN.

Naturally there are differences of opinion regarding some details as to how visual corrosion criteria should be evaluated and reported. The important thing is that *we agree that corrosion can be evaluated in a reliable and helpful manner by visual methods*. We are in substantial

agreement as to what are the essential corrosion criteria and their general types. The most important details such as differentiation between local attack and general corrosion are not subjects of disagreement.

Disregarding differences of nomenclature and wording, there are actually only two details concerning which there are important differences of opinion. The first relates to how many degrees of intensity or extent of corrosion may be readily differentiated by visual inspection. Since 1939 our laboratory has evaluated several thousand test panels. These included ferrous, non-ferrous, and bimetallic combinations, exposed in aqueous media for long periods of time under a variety of controlled conditions. In all cases the exposed specimens were evaluated by four independent observers, one of whom was the author. It was found impossible to obtain agreement when it was attempted to differentiate between more than about four degrees for each type of attack, namely, none, slight, moderate, considerable. We do not believe that other independent observers could agree on seven degrees, much less half-degrees as Mr. Champion has suggested; nor have we found any necessity for more than four or five degrees of attack, provided the types of attack are identified.

The second difference of opinion relates to the manner of scoring. In practice it has been found that the weightings shown in Form 1 have wide application; but, as we have previously mentioned, these weightings may be changed, or certain corrosion criteria disregarded depending on the specific application. At times it is convenient to employ the descriptive words given in Table II, but this is not an essential detail. There is some need for such descriptive words since the engineer who makes the final selection wants to know the following: first, which are the "good" panels; and, second, what is the order of merit of the "good" panels, in order that cost may be balanced against merit for any particular material of construction or manner of treatment.

<sup>2</sup> Research Laboratories, The British Aluminium Company, Ltd., Chalfont Park, Gerrards Cross, Bucks, England.

<sup>3</sup> F. A. Champion, "New Methods for the Examination of Corroded Metal," *Journal, Inst., Metals* (London), Vol. 69, pp. 47-66 (1943).

<sup>4</sup> F. A. Champion, author's closure for paper referred to in footnote 3, *Ibid.*, Vol. 69, pp. 495-502 (1943).



## Discussion of Paper on Mechanism of Rusting of Low Alloy Steels in the Atmosphere<sup>1</sup>

MR. G. L. COX<sup>2</sup> (by letter).—Mr. Copson is to be congratulated upon the development of a rational approach to the complex phenomena surrounding the corrosion of steel of the type characterized by "rust" formation. His contribution is, indeed, a worthwhile and timely one. It is particularly timely because of the current great diversity of interest in atmospheric corrosion resistance of a gamut of commercial steels, and the extensive testing programs already under way for some years. Mr. Copson's treatment will go a long way toward providing a better basis of interpretation of results than previously available.

In his discussion of the 25-day Bayonne Rusts—Table V, Mr. Copson points out that "... the groundward rust also contains more iron . . ." In this connection, I should like to invite the author's attention to several papers, published some years ago, and dealing with some of the fundamentals and basic concepts of the formation of products of corrosion (rust) on iron and steel:

(1) Chappell, E. L., "Influence of Rust-Film Thickness Upon the Rate of Corrosion of Steels," *Ind. Eng. Chem.*, Vol. 19, p. 464 (1927).

(2) Brown, R. H., Roetheli, B.

E., and Forrest, H. O., "The Initial Corrosion Rates of Metals," *Ind. Eng. Chem.*, Vol. 23, p. 350 (1931).

(3) Forrest, H. O., and Roetheli, B. E., and Brown, R. H., "Products of Corrosion of Steel," *Ind. Eng. Chem.*, Vol. 23, p. 650 (1931).

(4) Roetheli, B. E., and Brown, R. H., "Corrosion Rates of Steel and Composition of Corrosion Products, etc.," *Ind. Eng. Chem.*, Vol. 23, p. 1010 (1931).

(5) Cox, G. L., and Roetheli, B. E., "Effect of Oxygen Concentration on Corrosion Rates of Steel and Composition of Corrosion Products Formed, etc.," *Ind. Eng. Chem.*, Vol. 23, p. 1012 (1931).

In these papers, though in their principal part dealing with other specific phases of corrosion of iron and steel, it is shown that where there may not be complete and free access to oxygen, for the corrosion reaction (Copson's formulas ( $x$ ), ( $y$ ), and ( $z$ )) the corrosion products may be forms of iron other than  $Fe_2O_3$  (with indefinite water of hydration), and such forms as  $Fe_3O_4$  and  $Fe(OH)_2$  or some intermediate product between  $Fe(OH)_2$  and  $Fe_3O_4 \cdot xH_2O$ . Should any of these latter types of "rust" be formed on the groundward side of the specimens, then the iron content of the whole rust product will be higher. Reference 3 above describes a method of spectrographic identification of the products in the rust film, and it is suggested that

Mr. Copson include such studies in his further investigation of this interesting and valuable project.

MR. H. R. COPSON (author's closure by letter).—It is pleasant to find the paper still arousing discussion. Unfortunately the references cited by Mr. Cox deal mostly with the immersed corrosion of steel in oxygenated water, which is a little different from atmospheric corrosion. The significance of the difference is appreciated when it is realized that low alloy steels do not show the great differences in corrosion rates in immersed corrosion that they show in the atmosphere. Nevertheless the bibliography in the paper was not intended to be comprehensive and any additional references are welcome.

In suggesting that variation in the state of oxidation of iron or of hydration of the corrosion products accounts for the observed variation in the iron content of the rust samples, Mr. Cox offers an obvious explanation. However, this explanation is really no explanation at all, because it still does not give any reason why there should be such a difference between rust samples from the skyward and groundward surfaces of the same specimen. It might be possible to speculate on this point, but as stated in the paper, "The reason for the higher iron content (of the groundward rust) is not understood."

<sup>1</sup> H. R. Copson, "A Theory of the Mechanism of Rusting of Low-Alloy Steels in the Atmosphere," *Proceedings, Am. Soc. Testing Mats.*, Vol. 45, p. 554 (1945).

<sup>2</sup> Empire State Section, Development and Research Division, The International Nickel Co., Inc., Rochester, N. Y.

## Discussion of Paper on Impact Testing of Plastics<sup>1</sup>

MR. C. WAINWRIGHT<sup>2</sup> (by letter).—We were interested to read the Bailey and Ward paper and feel that the authors have made a useful contribution to a subject which is of very great interest to the plastics industry. There are one or two points, however, where it appears that some misunderstanding has occurred although this may be because we have not fully understood the operation of the machine.

<sup>1</sup> A. Bailey and Owen W. Ward, "Laboratory Testing of Plastics—Small-Scale Impact Test," *ASTM BULLETIN* No. 140, May, 1946, p. 50.

<sup>2</sup> Chief Technical Officer, Bakelite, Ltd., Redfern Road Works, Tyseley, Birmingham, England.

On page 52 under "Calculation of Test Results" it is stated that the theoretical velocity of the ball at the point of impact was calculated to be 137.6 in. per sec. whereas a practical measurement of velocity obtained by observing the length of flight of the ball gave a figure of 106.5 in. per sec., a difference of 29 per cent. The authors attribute this difference to the effect of the column of air in the tube causing "viscosity, friction, and compressibility effects" but express some surprise at the magnitude of the difference.

It appears at first sight, however, that consideration has not been given to the rotational energy of the ball as when the ball rolls down the tube and its direction of motion becomes horizontal, its initial potential energy  $mgh$  becomes translated into an energy due to its forward motion together with an energy of rotation in accordance with the expression  $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ .

From this the derived expression for forward velocity is  $\sqrt{\frac{2gh}{1.4}}$  and not

$\sqrt{2gh}$  as for a freely falling body.

Using the expression  $\sqrt{\frac{2gh}{1.4}}$  the theoretical velocity is calculated to be 116 in. per sec. which is only about 9 per cent greater than the observed velocity, a difference which is perhaps more acceptable in terms of friction and windage losses.

Another difficulty which has occurred to us is that when the ball strikes the specimen it may stop rotating, or may lose a proportion of its rotational energy in which case the energy of the blow would be exactly  $mgh$  less any friction and windage losses.

If this is so it would not be correct to estimate the energy absorbed in breaking the pieces from calculations based on the distance of flight of an unimpeded ball, as the unimpeded ball would almost certainly be rotating, when the distance of flight would correspond to the energy of  $mgh - \frac{1}{2} I\omega^2$ .

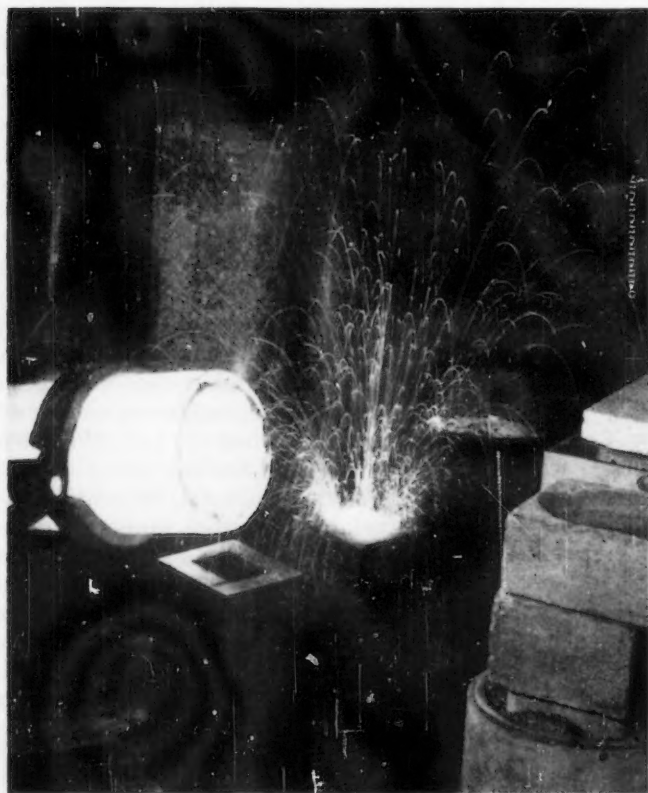
These points are raised on theoretical grounds only and as mentioned previously it is possible that we have not fully understood the

method of operation of the apparatus in which case our arguments may not be relevant. If this should be so we offer our apologies but in any case we consider the paper very interesting and we propose to carry out some experiments ourselves using the principles suggested by Messrs. Bailey and Ward as a basis for the measurement of the energy absorbed in breaking the standard notched impact test specimen used in this country.

It has been our experience that the impact strength of the rather brittle types of mineral-filled phenolics cannot be satisfactorily measured on the conventional type of pendulum machine and the falling weight method is not a very satisfactory substitute on account of the very large number of test specimens required. The method suggested by Messrs. Bailey and Ward might offer a satisfactory solution to the difficulty.

MR. A. BAILEY (*author's closure by letter*).—I appreciate Mr. Wainwright's constructive and interesting remarks. I should probably note

that our aim was to develop a practical, workable test to apply quickly to a war project; thus we neglected theory and correlation. I surmise that Mr. Wainwright is correct in his deductions as to the absorption of energy in the rotation of the sphere and the reduction or termination of the rotation when the sphere strikes the specimen. Although our activities at the time of development were limited to practical considerations and would not permit investigation of theoretical aspects of a war project, I would like very much to see Mr. Wainwright develop this important phase of the test. I should mention, and hope that Mr. Wainwright will attempt to duplicate, our observation that major differences in the actual lengths of flights were obtained by using spheres of different diameter in a tube of constant diameter, thus leading us to postulate viscosity, friction, and compressibility effects as possible causes. The rotation, as Mr. Wainwright suggests, is undoubtedly another cause, and further work might reveal others.



"Blowing of a Molten Alloy Melt"

Second prize-winning photograph, Nonprofessional, in the Fifth A.S.T.M. Photographic Exhibit, by Don W. Glasser, Westinghouse Electric Corp. Research Laboratory



## Professional Development of The Young Engineer

...WHAT can the engineer do to help the young graduate as he first enters engineering practice? Advice is not always taken and is sometimes resented, although the right word at the right time has influenced many a life for the better; and paternalism and regimentation have had their unsuccessful day.

The direct relationship between employer and employee is perhaps the best field in which the older engineer can help the younger. By advice and example he can help the young man to become a better engineer. He can watch for talent and can delegate responsibility as fast as it can be taken. He can induce the young man to attend engineering meetings, to take part in discussions; to work on committees, and can show, rather than advise, that these activities help in one's professional development. Many engineering firms have a more or less official policy of developing their engineers, and others could do so to advantage. While the employer is not to be a godfather to every man he hires, still by his word and attitude he can do much to inculcate the broad development so indispensable to the educated engineer.

...Men can take evening engineering courses of college grade.... Men feel that they are progressing when they are learning something; and refresher courses for the men who have been out of touch with engineering, and other courses for those who wish to expand their knowledge, will find a hearty response. This type of opportunity would do more than anything else to improve morale and to make the individual feel that his education is not over. Thus, by helping the young engineer to advance in his profession, by showing him that there is a future for any man who is capable and willing to work, by putting before him the means of attaining advancement, by keeping in mind that the young designer of today is the engineer of tomorrow, engineers will not only help the individual, but will work to the everlasting benefit of their profession.

Excerpted from an editorial prepared by the New England Engineering Societies' Committee on Engineering Education and Professional Development, published in the April 29 ESNE Journal.

## Reinforcements of Science

THE following excerpts are from a short article entitled "Reinforcements of Science" appearing in the American Cyanamid Company's Circular "For Instance" No. 24—1946. After referring to the tremendous increase in the amount of money being spent on research and the number of laboratories and scientists, which figures indicated that in 1940 there were at least 70,000 scientists and technicians working in 2350 laboratories, the article continues. "...Modern business has learned how well it pays to 'know its onions' within its logical field. ...

"The findings of the thousands of researchers who have thus been added to the armies of science do not remain secret. In chemistry, reliance upon secret processes without exhibition in patents is becoming very rare; modern analytical methods penetrate too easily the 'chemical blankets' of a generation ago! To protect new inventions, patents are commonly applied for but they must be applied for promptly and are usually pressed to early issue, whereby the knowledge, if not the rights, becomes public property and a stimulus to rival workers. ...

"The promptness and swiftness of the utilization of inventions developed by corporation research constitute another important credit to the public benefit. The new invention is commonly related to the sponsor's older products already in competitive manufacture, and the sponsor has not only the incentive but the equipment and skilled workers for a fast getaway.

"In the area of investigational methods, industrial technicians exchange their new ingenuities with about as easy a freedom as do workers in college laboratories. An improvement in a laboratory instrument, a short-cut in analysis, the establishment of a new basing point for comparative evaluations are published speedily and unreservedly in technical publications and convention papers so that all may employ the new techniques.

"On every point, the public is the gainer by the coming of the great industrial reinforcements of scientific inquiry."

## Report of the 1946 Winter Congress of the Association for the Advancement of Spectrographic Methods

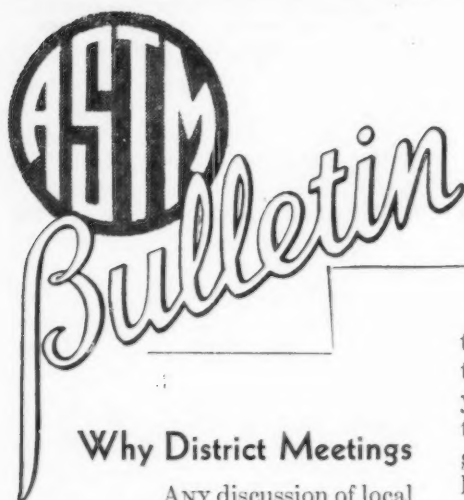
A COPY of the Proceedings of the Fifth Congress of the French Association for the Advancement of Spectrographic Methods for Metal Products has been received. This gives a list of those members attending, some notes on the sessions, and includes the papers and discussion presented. This 72-page pamphlet was printed by M. Schiffer, 56, Passage du Caire, Paris, France, and copies of the report undoubtedly can be obtained from him, or by contacting the Centre de Documentation Siderurgique, 12, Rue de Madrid, Paris, 8e, where the technical sessions were held.

*Membership in national engineering societies should aid the young engineer in developing self-confidence; in expressing abilities of an organizational nature; in providing informal association with senior members; in encouraging further study and greater achievements; in keeping abreast of engineering developments and in becoming a vital part of these developments. On the other hand, your enthusiasm, varied points of view, and fresh outlook should be of inestimable value to your profession, recognition of which is made possible not only by the endeavors of individuals, but their collective effort as well.—L. K. SILLCOX, New York Air Brake Co. in his Lincoln Lecture at Ohio State University. Published in the Journal of Engineering Education, May, 1946.*

## "Fungus Colonies Growing on Plastic Film, Canal Zone"

Second prize-winning photograph, Professional, in the Fifth A.S.T.M. Photographic Exhibit, by Frankford Arsenal Studios, Fungus Section





OCTOBER 1946

NO. 142

NINETEEN-SIXTEEN  
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### Why District Meetings

ANY discussion of local meetings, at some stage or other always invokes the comment "Well, there are so many meetings scheduled I can't possibly get to one-tenth of them." To be sure, with the local chapters of large numbers of the professional and technical societies holding monthly meetings, and with civic, school, and other types of meetings, those affiliated with A.S.T.M. are bound to have a heavy docket of gatherings they might attend, and some which they feel it essential to attend. The question then, of why A.S.T.M., through its local districts, attempts to schedule local or district meetings is a pertinent one, and one which we feel merits an answer.

First of all, the Society cannot be accused of having many additional meetings, since the districts by and large sponsor only two a year—usually one in the fall, and another in the spring. These meetings have a definite aim in bringing to the local members some outstanding technologist to talk on a subject bearing directly on A.S.T.M. work in the field of materials. The pending Philadelphia meeting, for example, dealing with industrial waters is not intended to be a meeting where the expert on water and water analysis and treatment will get much additional information, but everyone present, whether a metallurgist, civil engineer, or petroleum chemist, will be brought up to date on what some of the most recent problems are, and also how these are solved with modern methods, materials and equipment. It is believed that the educational nature of the A.S.T.M. local meetings is most important.

Aside from the other considerations, the Society officers feel that there should be an opportunity each year for the local members to greet the President, and particularly to get to know one another. There is little enough opportunity in the Society for members to fraternize. Even at the Annual Meeting and during the Spring Committee Week, most of the members and committee people are so busy with technical sessions and committee business, that they have little opportunity to say more than "Hello—how are you?" District meetings do help in getting members better acquainted.

These local meetings further provide an opportunity for Society officers to present to members a few of the highlights of the Society activities. No matter how many details are published in the BULLETIN or in reports or elsewhere, a direct verbal accounting has much to commend it.

Every member, committee member, and BULLETIN reader who possibly can, is urged to attend the various meetings which are being announced elsewhere in this BULLETIN.

### All Items on Ballot on Standards Approved

WHILE all items referred to the membership in the 1946 letter ballot the results of which were canvassed on September 16 have been approved, some few of them are subject to confirming letter ballot in the technical committees. Frequently new actions which are

proposed at the Society Annual Meeting, are approved by the Annual Meeting session subject to favorable letter ballot in the committee.

The 1946 ballot includes 50 tentatives recommended for adoption as standard and revisions in 148 existing standards. Details of these changes were given in the reports of the technical committees distributed to the membership on request and in the *Summary of Proceedings* which went to all members.

All of the standards will, of course, appear in the 1946 Book of Standards, the preparation of which is now under way. This is to be issued in five volumes instead of the three books which contain the 1944 standards and full details will be furnished the members on the new setup. The books will not be available until late December, or the first month or two of next year, but in the meantime many of the revised specifications and tests can be procured in separate pamphlet form.

### Headquarters Building in Final Stages

EACH passing week has brought nearer the time when it can be stated "the Building is finally finished," but the time has not yet quite arrived. The Board Room and Committee Rooms are completed and have been used for meetings; in fact, the Board of Directors at its sessions on October 7 and 8 made use of the facilities and there was general commendation on the arrangement and the furnishings. No one has stepped into the Headquarters without exclaiming on the very fine appearance. The Office Manager and Receptionist are in their places in the front portion of the building, the Members' Room has been completed, and before too long the Executive Secretary will be in his front office. There will be left the major job of installing air-conditioning equipment which can be done without interference with staff operation, the ducts and piping having been pretty much completed.



## Numerous District Meetings Planned

**Topics: Materials?; Industrial Waters; Progress in Rubber; Testing Materials with the Atomic Bomb; Atomic Energy.**

WITH the coming of fall, the various A.S.T.M. District Committees functioning in industrial centers throughout the country renew their activities after the summer lull. To give all A.S.T.M. members some information on the meetings that are being developed under District auspices, notes appear below. The holding of local meetings, frequently joint affairs with sections or chapters of other engineering and professional societies, is one of the means by which Districts stimulate interest in A.S.T.M. work, and bring the Society to local members, many of whom cannot attend national meetings. At the same time, these meetings provide an opportunity for the A.S.T.M. officers, particularly the President and Executive Secretary to meet the members, keep in touch with some of the ideas and problems which are arising in the materials field, and also the meetings give members an opportunity to get better acquainted with those who are guiding the destinies of A.S.T.M.

While some of the notes which follow are general at this time, it should be kept in mind that all members in the respective districts will receive direct mail notices of the various gatherings. However, all members are cordially invited to attend any of these meetings, in case they are in the locality when the sessions are being held. During the past year it has been frequently the case that some of our people would attend local meetings from considerable distances.

### Detroit

At the meeting in the Rackham Memorial Building on November 13, the topic to be discussed by Arthur R. Maupin, Metallurgical Engineer, Civilian Production Administration, will be "Materials—Where Are They"? Mr. Maupin, who for several years was connected with the War Production Board, actively participating in the materials

branches, has just returned from an extensive trip, and should be in a splendid position to present pertinent facts on the production and distribution of materials. There is probably no more pressing problem in the country at this time than the shortages which crop up, seemingly here, there, and everywhere, thus reducing production and having an adverse effect on our economic gains.

### Cleveland—Pittsburgh—Chicago

At meetings to be sponsored in Cleveland on November 7, Pittsburgh on December 2, and Chicago, January 7, 1947, President Arthur W. Carpenter, Manager of Testing Laboratories, B. F. Goodrich Co., Akron, Ohio, will speak, and joining him on the program will be H. N. Stevens, who witnessed the atomic bomb tests off Bikini. Mr. Stevens, Coordinator, Research Division, The B. F. Goodrich Co., will present an intriguing topic "Testing Materials with the Atomic Bomb." He will have many interesting comments and his talk will be illustrated with numerous slides, and other material. President Carpenter will cover the topic "Progress in Rubber." He will discuss the policy which we should follow in connection with American rubber as compared with crude rubber. He plans to give a concise picture of the present status of the industry, both with respect to production and the utility of the materials. In addition, he will refer to some of the newer applications of these materials, emphasizing improvements in quality of American-made rubbers which have already been realized, and the advantages resulting from being able to modify their properties to meet specific problems. Mr. Carpenter plans to have his talk a down-to-earth type, which will give interesting information to members and those at the meeting, whether they be metallurgists, chemists or whatever their particular industry may be.

### Philadelphia

While Philadelphia is planning four meetings during the year, two are of immediate interest, since they will be held on November 14, and January 23, 1947. The first of these meetings (both will be held in the Lecture Hall of the Franklin Institute) involves the subject of Industrial Waters. L. Drew Betz, active member of the District, is arranging this meeting, and will introduce the chief technical speaker, John J. Maguire, Director, Technical Division, W. H. & L. D. Betz, Philadelphia. These two men have been giving a series of technical lectures throughout the country, and with the subject of water one of current interest in Philadelphia at the present time, even though primarily from the standpoint of drinking water supply, this subject seemed to be a "natural" for the District. Messrs. Betz and Maguire will devote the major part of their discussions to water impurities, and treatment of water for the various industries. There will be shown a large number of slides and illustrations.

Again this meeting is planned to be of interest to every engineer, no matter what his particular branch may be.

The meeting on January 23, 1947, will involve gas turbines and related equipment, stressing two phases—first the applications and future implications of this development, accelerated by wartime needs—and secondly, the ability of the engineer to supply needed materials, which in gas turbines and such equipment must operate at extremely high temperatures with highly concentrated stresses. A. O. Schaefer, District Vice-Chairman and Executive Metallurgical Engineer, Midvale Co., Philadelphia, is in charge of the program, and two outstanding speakers are being invited to take part.

### St. Louis

The meeting to be held under the



I. to r. G. L. Oliensis, Chairman; A. W. Brust, Vice-Chairman; and S. B. Roberts, Secretary, St. Louis District Committee.

auspices of the St. Louis District, the first there for some time, will feature Timber as an Engineering Material, but will emphasize the widespread applications of timber as a composite with many other materials, thus increasing its utility. L. J. Markwardt, member of the A.S.T.M. Board of Directors, and Assistant Director, U. S. Forest Products Laboratory, Madison, Wis. will give this lecture, replete with exhibits and other material. A world authority on the subject, Mr. Markwardt's talk will be of interest to anyone who is concerned with the materials field.

This meeting will be a joint one with the St. Louis chapter of American Society of Mechanical Engineers, and is scheduled for 8 o'clock in the Stockholm Room of the Park Plaza Hotel, St. Louis. Messrs. G. L. Oliensis, Director of Research, Lloyd A. Fry Roofing Co., Madison, Ill., and S. B. Roberts, District Manager, Robert W. Hunt Co., St. Louis, respectively District Chairman and Secretary, are hoping there will be a good attendance of Society members to greet Mr. Markwardt, and also to meet President Carpenter and Executive Secretary Warwick who plan to be present.

#### New York

The New York District has been very fortunate in securing Prof. J. R. Dunning, Department of Physics, Columbia University, New York, an outstanding authority on atomic physics, to give his lecture on atomic energy including results of recent test investigations. This meeting is to be held in Room 501 of the Engineering Societies Building, 29 W. Thirty-ninth St., at 7:30 o'clock on December 12. Members of other societies will be invited to attend this meeting and a capacity audience is anticipated. Professor

Dunning has a wide reputation as an interesting speaker and supplements his lecture with models and demonstrations. The A.S.T.M. members and committee people in the New York area are urged to get to the meeting early so that they will be assured of a comfortable seat should it be an overflow meeting.

#### Western New York-Ontario District Officers and Members

WHILE the August BULLETIN announced the officers and new members of the various District committees, information for the Western New York-Ontario group was not included. Based on action by the committee and appointments by the Society President, the new officers and members follow:

Honorary Chairman: B. L. McCarthy,\* Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., Buffalo, N. Y.  
Chairman: T. L. Mayer,\* Department of Technology, Buffalo Public Library, Buffalo, N. Y.

Vice-Chairman: O. W. Ellis, Ontario Research Foundation, Toronto, Ont., Canada

Vice-Chairman: L. V. Foster,\* Bausch & Lomb Optical Co., Rochester, N. Y.  
Secretary: Joseph Gentile,\* Pittsburgh Testing Laboratory, Buffalo, N. Y.

The following have been appointed to the Committee:

J. F. Barton,\* The Federal Portland Cement Co., Inc., Buffalo, N. Y.; O. W. Ellis, Ontario Research Foundation, Toronto, Ont., Canada; L. V. Foster, Bausch & Lomb Optical Co., Rochester, N. Y.; Joseph Gentile,\* Pittsburgh Testing Laboratory, Buffalo, N. Y.; L. F. Hoyt,\* Allied Chemical and Dye Corp., Buffalo, N. Y.; W. H. Lutz, Pratt & Lambert, Inc., Buffalo, N. Y.; Alden Merrill,\* American Brass Co., Buffalo, N. Y.; H. E. Seemann,\* Eastman Kodak Co., Rochester, N. Y.; and H. G. Swan,\* Gould Coupler Works, Symington-Gould Corp., Depew, N. Y.

\* Indicates new appointment, or new election in case of officers.

#### Offers of Papers for 1947

THE Administrative Committee on Papers and Publications will meet early in February to consider the papers to be published by the Society in 1947 and to develop the program of the 1947 Annual Meeting to be held in Atlantic City, N. J., June 16-20. All those who have in mind offering papers for presentation at the Annual Meeting and publication by the Society should send these offers to Society Headquarters no later than February 1.

All offers should be accompanied by a summary which should make clear the intended scope of the paper and indicate features that, in the opinion of the author, will justify its inclusion in the Annual Meeting program and publication by the Society. Suitable blanks to be used in transmitting the desired information will be sent promptly on request.

Technical papers are preprinted and distributed to the members throughout the year as they become available. In other words, manuscripts that are available early need not be held for printing just prior to the Annual Meeting. It is therefore urged that all manuscripts be submitted as early as possible for prompt distribution to the members.

There is one point which might well be kept in mind—the committee does not judge the contribution on the basis of length or comprehensiveness of the paper. A review of A.S.T.M. *Proceedings* and ASTM BULLETIN will indicate that a number of pertinent and important contributions are short, or relatively so.



I. to r. G. E. Stryker, Secretary, Chicago; F. P. Zimmerli, Vice-Chairman, Detroit; and F. T. Mavis, Vice-Chairman, Pittsburgh.



## Report on Transformer Oil Questionnaire—Reprints Now Available

THE results of a questionnaire on tests of transformer oil in service have been compiled by Subcommittee IV on Liquid Insulation, of Committee D-9 on Electrical Insulating Materials. The questionnaire was sent to 92 utility companies in the United States including a representative number of the larger utilities. The main purpose of the questionnaire was to establish what tests are regularly made by the various companies as criteria of serviceability of transformer oils in service, and the ranking of these tests according to their relative importance. The data and information received from the 67 companies who answered the questionnaire have been analyzed and are published in a

report which appears in the 1945 A.S.T.M. *Proceedings*, Vol. 45, p. 302. This report has recently been issued in reprint form.

The most significance was attached to which tests were listed as having importance. Briefly summarized, all of the 67 companies noted the test for dielectric strength as one that is always made; 58 companies listed neutralization number; 38 noted the color test and visual inspection for sludge or sediment; 22 regularly make the power factor test; 4 use the steam emulsion test, and 4 interfacial tension.

Especially emphasized was the question, "Is sludging of transformer oil a very serious problem today?" The general consensus indicated that sludging is not con-

sidered a serious problem chiefly because transformers, excepting most modern designs, are usually operated below full-load capacity in order to hold oil temperatures below values which would result in rapid deterioration of the oil. The main factor in limiting the load which a transformer can withstand is not the transformer itself or any part of its solid insulation but rather the liquid insulation. With present-day developments of more and more heat-resistant and chemically stable forms of solid insulation the limiting feature of the oil is still further exaggerated. Thus, the general conclusion is reached that an urgent demand exists at present for a liquid insulation which would be stable at relatively high temperatures.

Reprints of the complete report of this oil questionnaire are now available from Society Headquarters at 25 cents each.

## Meeting on Gaseous Fuels

COMMITTEE D-3 on Gaseous Fuels held a meeting in Atlantic City, N. J., on October 6.

The committee had available at its meeting reprint copies of the comprehensive Tentative Method of Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter (D 900-46 T) which had been accepted as tentative by the Society on September 9 through the Administrative Committee on Standards. This is the first A.S.T.M. method prepared by Committee D-3 and represents quite an important contribution. The test procedure is described in complete detail (48 pages) including a number of tables of data used in calculating calorific value.

A new method of sampling liquefied petroleum gases was approved for submission to letter ballot of the subcommittee on this subject. It is expected that this method will be completed for submission to the Society in 1947 as a tentative method. It was reported that methods are in preparation covering procedures for the sampling of manufactured gas and natural gas. It was also reported that a draft of a Proposed Method of Measurement of Gaseous Samples covering the use of wet laboratory meters had been

completed and would be studied by the committee prior to the next meeting in February. The project on determination of specific gravity and density of gaseous fuels has been completed and the results of the extensive tests made at the National Bureau of Standards are expected to be published in the near future in the *Journal of Research* issued by the Bureau.

The subject of water vapor content of gaseous fuels has been under active study by one of the subcommittees. At the meeting results were presented covering an investigation of a water vapor detector, the principle of operation of which is based on a change in conductivity of a film of phosphoric acid as affected by the absorption of moisture. The results were found to be fairly satisfactory on gaseous samples saturated at high pressures. The method is fairly rapid and not subject to interferences encountered in certain of the other methods. These studies will be continued.

A detailed report was presented to the committee on the very active project covering the complete analysis or composition of gaseous fuels. The results of cooperative tests by 30 different laboratories on two standard samples of gases have been

reported to the committee. The results of the tests on the first of these samples have recently been published by the National Bureau of Standards in the *Journal of Research* for March, 1946, as Research Paper RP1704 entitled "Analysis of a Standard Sample of the Carburetted Water-Gas Type by Laboratories Cooperating with the American Society for Testing Materials" by Martin Shepherd.

The reproducibility of the most important new instrument for gas analysis, namely, the mass spectrometer, is now being investigated by means of A.S.T.M. standard samples. This program was initiated before the close of the war by cooperation with the Rubber Reserves cross-check program. Approximately 30 laboratories equipped with different types of mass spectrometers were recruited for these cooperative analyses. Tests have been completed by some of the cooperators, and upon completion of the tests being made by the other laboratories, the data will be cross-checked with results obtained by conventional chemical analysis methods. Results reported so far give evidence that the mass spectrometer method must be given serious consideration in arriving at a tentative method for gas analysis.

# Standardization Projects

## Notes on Some "D" Committee Activities

THE material below is a continuation of an extensive article in the August BULLETIN intended to convey an idea of the large amount of standardization work which is either under way or in the planning stage in the A.S.T.M. technical committees. The August BULLETIN covered the "A" and "B" committees, the "C" group, and also some of the "D" committees which are concerned with nonmetallic nonstructural materials. Notes on some of the other "D" committees follow.

Altogether these articles indicate a tremendous amount of technical activity.

### Petroleum Products

COMMITTEE D-2 on Petroleum Products and Lubricants has formulated a broad program of work following three meetings held during the year in January, March, and June. At the Spring Meeting the organization of a new technical committee on light hydrocarbons was completed and there is now in the process of organization two new technical committees; one on aviation fuels and the other on cutting oils. An organization meeting of the new technical committee on aviation fuels will be held early in November. The technical committee on Diesel fuel oils is in the process of reorganization and it is expected to hold a meeting of this technical committee during the annual meeting of the A.P.I. in Chicago during the week of November 11.

The technical committee on turbine oils has been extremely active during the year and expects to present shortly recommendations for handling turbine oils containing rust preventives and antioxidants. Another section of this technical committee has under completion a proposed tentative method of test for oxidation resistance of turbine oils.

The Subcommittee on Sampling and Gaging has been reorganized and its work will now be carried on by the following new sections: (1) Sampling Procedure, (2) Measuring Apparatus and Calibration, (3) Temperature Measurements, (4) Units of Measurements and Correction Tables, (5) Tank Calibration, and (6) Sampling.

The Subcommittee on Hydrocarbon Types continues extremely active and has completed this year a Proposed Method of

Test for Aromatics in Mixtures with Naphthas and Paraffin by Silica Gel Adsorption, which has been published as information. A new Tentative Method of Test for Olefins and Aromatics in Petroleum Distillates, resulting from a revision of Emergency Method ES-45a, was also submitted as tentative. This committee expects to submit shortly for publication new methods for olefin and saturation by chemical means, density test by the pycnometer, freezing point test for purity, and spectrometer methods of analysis using ultraviolet and infrared equipment.

At its June meeting Committee D-2 received reports from its subcommittees covering the status of cooperative work on the following subjects: congealing point of paraffin wax, color, sulfur, inorganic elements in lubricants, neutralization number and saponification, petroleum sulfonates, and nomenclature. The viscosity subcommittee reported that work is being undertaken on a method of test for viscosity at varying rates of shear due to the increased use of additives of various types and the possible introduction of synthetic oils.

### Coal and Coke

Committee D-5 has also initiated plans for a very active program of work, as evidenced from the following summary of its work.

The Subcommittee on Nomenclature and Definitions has under consideration the formulation of definitions of "coking," "caking," "inherent moisture," "surface moisture," and "free moisture." "Coking" and "caking" have been used more or less synonymously but often they are intended to imply different characteristics so the terms require clarification, particularly for use in connection with coal carbonization and coal combustion. The different forms of moisture in coal are important in affecting carbonization properties and in shipment during cold weather when freezing affects handling properties of coal.

The Subcommittee on Pulverizing Characteristics of Coal will investigate a method for determination of particle size by means of resistance to air flow. The method under consideration is simple and rapid. If satisfactory it will shorten considerably the procedure of estimating particle size which at present is limited to sieving methods which are prescribed in the tentative standards on methods for determination of pulverizing characteristics of coal.

Investigation of methods of test for determination of ignitibility of coal and coke is being continued. The standardization of a test method presents a difficult problem. Much work has been done but no method has been developed that can be considered as satisfactory for publication as tentative. The experimental work is still in the research stage.

The Subcommittee on Sampling and Fineness Test of Pulverized Coal was recently organized and delegated to revise the present Standard Method of Sampling and Fineness Test of Powdered Coal (D 197). The present procedure of sampling pulverized coal needs extensive revision and the laboratory method of sieve analysis also requires revision. The subcommittee will cooperate with a power test code committee of the A.S.M.E.

Work on a revision of the Tentative Method of Drop Shatter Test for Coal (D 440) is under way. At present, the scope of the method recommends using 2 by 3-in. size coal as the standard size for testing relative friability of different coals. Experience has shown that this may give anomalous results with some coals.

Another subcommittee is collecting data pertaining to the degree of accuracy that may be expected in sampling coals by the procedure given in the Method of Sampling Coals According to Ash Content (D 492) (adoption as standard this year). The accuracy specification states that the sampling procedure is designed for an accuracy such that if a large number of samples were taken from a single lot of coal, the test results in 95 out of 100 cases would fall within plus or minus 10 per cent of the average ash content of these samples. This accuracy specification is based largely on the experience of engineers and chemists with extensive knowledge of coal sampling. Only a limited amount of data is available for statistical studies, and it would be very desirable to continue coal sampling experiments. Due to the expense and labor involved in experimental coal sampling, it is uncertain just how much can be accomplished in the immediate future.

The committee has under consideration a proposal to recommend for publication as tentative the Proposed Method of Test for Plastic Properties of Coal by the Gieseler Type Plastometer, as published for information in the Appendix to the 1943 Annual Report of Committee D-5. Before action is taken, a subcommittee will conduct cooperative tests to determine how closely different laboratories can check on the same samples of coal.



## Soap and Other Detergents

Committee D-12 has initiated work on several new projects which, when completed, will result in several important additions to its present group of standards. Several of the more important projects in its current program are briefly described below.

The Section on Methods for Chemical Analysis of Detergents used in dry cleaning and performance tests for the evaluation of such detergents, has outlined a program in which it will seek the aid of manufacturers of such products. The nature of these detergents is so diversified that no single set of methods has been found which is applicable to all of them. The section hopes to classify them and develop methods for each of the several classifications.

The Sections on Methods of Chemical Analysis and Specifications of Special Detergents are preparing specifications and methods of test for Borax (sodium tetraborate) and sodium bicarbonate. It was deemed inadvisable to write specifications and methods for potassium hydroxide, potassium carbonate, and sodium orthosilicate at this time, hence, this work will be held in abeyance.

The Section on Metal Cleaning Detergents has written methods for the chemical analysis of such compounds and has done considerable work on performance tests for them. A program of cooperative testing has been formulated which, it is hoped, will make it possible to standardize one or more tests for the evaluation of these materials.

Probably the most important item on the program of Committee D-12 is the development of a method or methods for the evaluation of detergency. While this problem is of the utmost importance in industry it is at the same time the most vexatious. It has been worked on by various groups and individuals for many years and some procedures have been published which were deemed satisfactory by the authors. None of these, however, has won acceptance by either the textile or detergent industries. During the past few years several of these procedures were made the subject of cooperative tests by the committee and, while some seemed to offer promise, the committee could not come to any agreement concerning them largely because many of the members demanded too great a degree of precision.

The committee has accordingly formed a new Section on Methods of Physical Testing and it is believed this program will develop one or more tentative methods for the evaluation of detergency within the next year or two.

## Conductive Rubber

### Work Being Undertaken by ASTM-SAE Technical Committee on Automotive Rubber

INCREASING interest in so-called "conductive" rubber, a product which, in contrast to the usual type of rubber is a conductor of electricity, and is coming into widespread usage, particularly in automotive and related applications, has led Technical Committee A which functions under the sponsorship of the S.A.E. and A.S.T.M. to organize a new committee on this material. S. R. Doner, Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., is the chairman of the group which is functioning under Section 4 concerned with the classification and specifications of rubber compounds. Technical Committee A is part of A.S.T.M. Technical Committee D-11 on Rubber and Rubber-like Materials.

In the late 30's it was found that by compounding acetylene black into rubber, a soft rubber could be made to conduct an electric current and still retain the other normal rubber characteristics such as tensile strength, elongation, and hardness. In recent years many conductive channel-type carbon blacks have also been developed which are used extensively by the rubber industry.

Conductive rubber has found many applications in industry as a means of eliminating static discharges. The use of electrically conductive rubber for elevator, transmission, and conveyor belts aids in eliminating fire and explosion hazards. The soft rubber nozzle used on many gasoline dispensing pumps at filling stations to eliminate the possibility of a static spark is another use.

Formerly bus passengers might have received an electric shock of varying intensity when boarding a bus immediately after it had stopped. This condition has been

corrected by using tires with conductive sidewalls and tread.

During the war, conductive rubber was used for matting, belting, truck tires, shoe soles, and many other items in munition plants and thus contributed toward the low accident rate in munition production.

More recently, conductive rubber has been used directly as a heating element. Some applications are ice eliminators on the leading edge of aircraft propellers, heating pads, and even baby chick brooders.

Conductivity in a rubber compound is probably secured by actual contact of the carbon black particles. If a conductive rubber strip is stretched its conductivity is reduced, and if compressed its conductivity is increased. Within limits, the better the milling process to disperse the carbon black and other materials, the better the physical properties; but with electrical conductive rubber the more the compound is milled (in the uncured state), the poorer are its electrical conductive properties. These various factors make it difficult to develop exact electrical conductive specifications. However, it has been found that when a rubber compound possesses enough conductivity to cause a 2-w. neon bulb to glow when a 110-v. current is passed through it, the rubber is sufficiently conductive to eliminate or dissipate static electricity when such a compound is used in transmission and conveyor belts, matting, sand blast hose, tires, etc.

In anticipation of its increased use, the new committee has been formed to study means of determining the conductivity or resistivity of conductive rubber and to propose specification limits that are commercially practical.

## ASTM Forum on Diesel Fuels

A HIGHLIGHT of the gathering of the nation's oil men during the American Petroleum Institute's annual meeting at Chicago in mid-November is a Forum on Diesel Fuels to be held at 10

A.M. November 13, in the ballroom of the Blackstone Hotel.

Invited to participate are the Association of American Railroads, the American Petroleum Institute, The American Society of Mechanical

Engineers, the American Trucking Associations, Inc., the Diesel Engine Manufacturers Association, the Gulf Coast Refiners Association, the National Petroleum Association, the Society of Automotive Engineers and the Western Petroleum Refiners Association.

The forum, according to Chairman E. W. Isom, Sinclair Refining Co., will explore both present and future operation of Diesel equipment and the situation obtaining in distillate fuels by geographic distribution.

The forum will be under the direction of Technical Committee F on Diesel Fuels of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

The program:

#### FORUM ON DIESEL FUELS

MORNING AND AFTERNOON, NOV. 13,  
CHICAGO

Chairman: E. W. Isom, Vice-President,  
Sinclair Refining Company

- I. Introduction—E. W. Isom
- II. Post War Military Trends—Colonel G. H. Vogel, Army-Navy Petroleum Board
- III. Diesel Fuel in Railroad Operation—W. W. Kelly, General Purchasing Agent, Atchison, Topeka and Santa Fe Railway System
- IV. Diesel Power in Bus Operation—F. T. Ward, Chief Engineer, Third Avenue Transit System, New York City
- V. Increasing Diesel Horsepower vs. Diesel Fuel Supply—Robert H. Morse, Jr., Vice-President, Fairbanks, Morse & Company

#### Adjournment for Lunch

- VI. Engine and Burner Distillate Fuels—Now and In the Future—John C. Day, Secretary, Western Petroleum Refiners Association
- VII. East Coast Distillate Fuels—Joseph E. Keller, Attorney, National Petroleum Association
- VIII. Distillate Fuels—West Coast—A. G. Marshall, Shell Oil Company

## Bingham Memorial Symposium—Society of Rheology

A MEMORIAL symposium to the late Dr. E. C. Bingham will be held at the Annual Meeting of the Society of Rheology on November 1 and 2 at the Hotel Pennsylvania in New York, N. Y. The symposium will honor the memory of Dr. Bingham, an authority and pioneer in the science of rheology and one of the founders of the Rheology Society. This symposium will be of considerable interest to members of A.S.T.M. since the technical papers comprising the symposium will cover the entire field of rheology and will bring up to date the developments that have taken place since the Symposium on Consistency sponsored in 1937 by the A.S.T.M. through Technical Committee II, of Committee E-1 on Methods of Testing. Dr. Bingham was chairman of this technical committee for twenty years prior to his death in November, 1945.

The symposium papers will be presented in three sessions; two on Friday, November 1, and one on Saturday, November 2. In the opening session Mr. W. H. Fulweiler, Chairman of Committee E-1, will present a paper entitled "E. C. Bingham and the A.S.T.M.—An Appreciation," in which he will pay tribute to Professor Bingham and review briefly his many activities and contributions in this field of endeavor during his affiliation with the Society.

The seventeen papers to be presented in the three technical sessions will cover the following subjects: rheological theory, polymers, plastics, flow under high pressures, temperature and high concentration dependence, statistical analysis, rheology of asphalts, tars, pitches, lubricants, paints, varnishes, lacquers, printing inks, rubbers and glasses, viscometers and viscosity standards.

Members of the Society are cordially invited to attend this symposium and also a social meeting which will be held on Friday evening, November 1.

## Cement Reference Laboratory Inspection Tour

THE Cement Reference Laboratory at the National Bureau of Standards is now planning another tour of inspection among the cement testing laboratories throughout the country. Laboratories that desire to avail themselves of this service should promptly address their requests to the Cement Reference Laboratory, National Bureau of Standards, Washington 25, D. C. This inspection service is at present quite closely confined to the apparatus and methods employed in the standard physical tests of hydraulic cement, and does not include concrete testing.

The Cement Reference Laboratory is jointly sponsored by the Bureau and Committee C-1 on Cement for the purpose of aiding and promoting uniformity and general improvement in cement testing. Through the close cooperation given the Laboratory, it is apparent its work has been very favorably received and unquestionably has been beneficial from the standpoint of all interests concerned. Several extensive tours have been made by representatives of the laboratory.

## Executive Secretary Speaks at N.I.G.P. Meeting

AT THE annual conference of the National Institute of Governmental Purchasing, held in Chicago in August, A.S.T.M. Executive Secretary Warwick spoke on "The Importance of Standards and Specifications in Governmental Buying," his talk being given on August 21. After reviewing the various definitions of a specification and covering the advantages of specifications in buying, he referred to some of the distinctive differences between industrial and governmental buying practices and objectives. He pointed out that the value of purchase specifications is enhanced when standardized requirements are available and understood by the buyer and the producer. The importance was stressed of having Government and industrial specifications similar in as many respects as possible. He referred to the work of the Federal Specifications Board and its Industry Advisory Council which is aimed to establish a closer relationship between industry and technical societies on the one hand, and the F.S.B. on the other.

He discussed the great opportunity for constructive work which faces the National Institute of Governmental Purchasing in assisting specification-writing bodies to interpret clearly the viewpoints of Government buyers, and stated that the N.I.G.P., through its Committee on Standards and Tests could indicate the



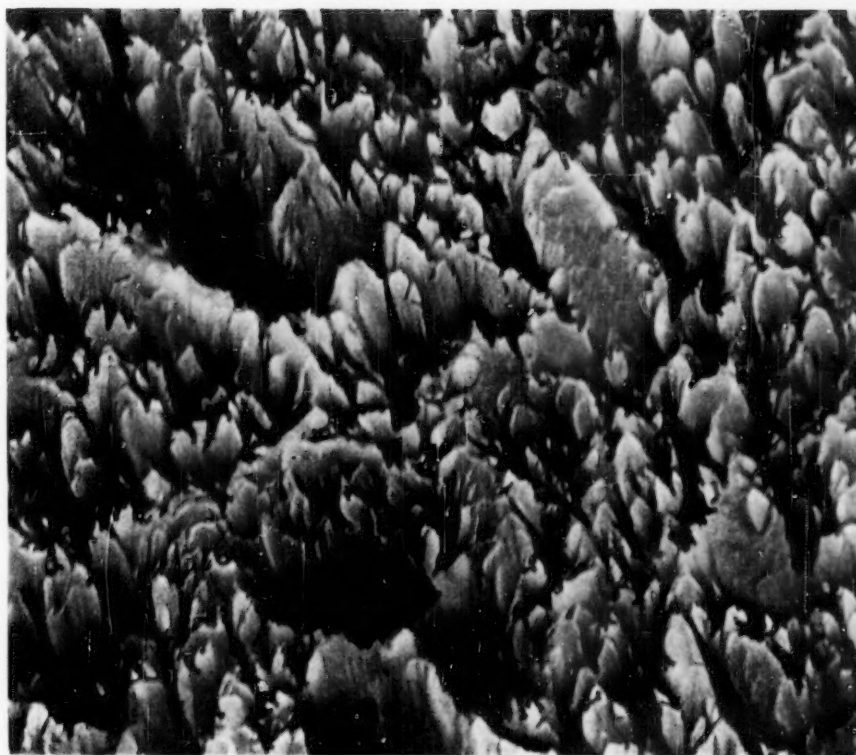
needs of the public buyer for certain types of simplified standards and specifications. He concluded: "Accordingly A.S.T.M. sincerely welcomes the N.I.G.P. as representing an important group of buyers, and looks forward to its help in developing standards and specifications of greatest value to the governmental buyer. You may be sure of the desire of A.S.T.M. to assist in every way it can in attaining the high purposes and objectives of your Institute."

**"Replica of Quenched, Tempered and Etched Steel, Showing Tempered Martensite X32,000"**

First prize-winning photograph, electron microscope group, in the Fifth A.S.T.M. Photographic Exhibit, by Evelyn Gagnon, American Cyanamid Co.

**"Water Determination of Saponifiable Substances by Ether Extraction in Acid Solution"**

Honorable mention, nonprofessional, in the Fifth A.S.T.M. Photographic Exhibit, by Alfred Watson, Hall Laboratories, Inc.



**Fire Prevention Week Has Come and Gone, But—**

ONE thousand dollars worth of valuable property is being burned up in the United States every minute of the day at the present unprecedented rate of burning, according to the National Fire Protection Association. Fire Prevention Week, set by proclamation of the President of the United States and Governor General of Canada, was the week of October 6 to 12. According to the NFPA, sponsors of Fire Prevention Week, fire losses in the United States for the 12-month period ending June 30, 1946, were \$519,244,000 as against \$442,877,000 for the previous twelve-month period. Fire Prevention Week this year marked the seventy-fifth anniversary of the Great Chicago Fire of 1871.

This year, 1946, also is the One-Hundredth Anniversary of the founding of the NFPA. The Association is interested in a number of phases of A.S.T.M. work and Robert Moulton, Technical Secretary, holds membership in the Society.

**Not Too Important, But Interesting**

THE new Headquarters location is such that transmission of telegrams is expedited if they can be 'phoned in. Probably we are now as accustomed as we ever shall be to the telegraph operator who in repeating the title of the ASTM BULLETIN goes like this: "A" as in Adam "S" as in Sugar "T" as in Thomas "M" as in Mary BULLETIN—all at a mile a minute!

## Engineering Societies Council of New York Organized

THERE has been organized recently an Engineering Societies Council of New York, which is fundamentally an outgrowth of the Engineering Societies Committee on War Production, which has existed for the past four years. Composed at present of fourteen engineering societies, chapters of which are located in Metropolitan New York, its purpose is to promote unification to a greater extent of the engineering profession, and cooperate in any way possible with projects of member bodies.

The New York District of A.S.T.M. is represented on this Council through Myron Park Davis, Otis Elevator Co., A.S.T.M. District Chairman. Mr. Davis, who was secretary of the WPB group, is serving the new council in a similar capacity. G. O. Hiers, National Lead Co. District Secretary, is Mr. Davis' alternate on the council.

## The Metallurgy of Quality Steels

THE opening sentence in the foreword to this new book by Charles M. Parker, Secretary, General Technical Committee, American Iron and Steel Institute, will arouse immediate sympathetic understanding among large numbers of individuals who have been plagued by somewhat the same situation. It is stated "This book is the outcome of several years of answering questions, by telephone and by correspondence, posed by all sorts of persons from operating executives to school boys in knee pants." We are reminded of one query from a serious gentleman who wanted to know "all about the various kinds of steel and all about the ways in which steel is used."

Mr. Parker points out that his book is not designed as a substitute for more lengthy works but is intended rather as an introduction to some of the excellent texts which are available. One should expect a "down-to-earth" discussion of many of the topics covered, and that is what is given. Following a discussion of the general nature of steel, the relation of steel quality to manufacturing methods, chemical composition and control and rolling practices is discussed at length. Then follows material on inspection procedures and mechanical testing. Thermal critical points, heat treatment, and effects of alloying and incidental elements are covered trenchantly, and two topics which have

come very much to the fore in the past few years, namely, hardening and hardenability, are the subject of two chapters totaling about 40 pages. Some of the special characteristics of steel and general characteristics of standard grades are given, the latter including extensive lists of applications of the various grades.

In relation to describing or specifying steel the following comments in the opening chapter are significant:

"For many years it has been the custom of steel consumers and producers alike to describe steel in terms of its chemical composition limits and ranges. In the field of alloy steel this practice has been more pronounced than in the field of carbon steel, because alloy steels may contain many more elements which affect their range of usefulness than do carbon steels.

"The original reason for describing steel in this fashion was an attempt to define quality and secure reproducibility of results. In the early days of steel technology our knowledge of the effects of the several elements on the mechanical properties of steel was much more imperfect than it is today. It was thought that any two heats of steel, the compositions of which fell within the same chemical limits, would perform in the same manner.

"Today, we know that that is not true—selection of raw materials, melting practice, deoxidation practice, discard and surface conditioning practices, to name only a few major variables, have profound effects not only on the mechanical properties of steel but on the more intangible properties of 'personality' or behavior in such operations as forging, machining and heat treating.

"In order to understand the true meaning of steel quality, therefore, one must first consider carefully the job which the steel has to do rather than simply recording a list of chemical composition limits. The chemical composition is, of course, important but, as will be shown, it is possible to produce steels of widely varying qualities with exactly the same chemical composition production limits because of our ability to vary the interior physical condition of the steel and because the arrangement of the atoms of which the steel is composed plays a part at least as important as the quantity of the different atoms present."...

Copies of the publication aggregating 254 pages, with 163 figures, are available from the publishers, Reinhold Publishing Corp., 330 W. 42nd Street, New York, at \$6.00 per copy.

## Brochure on Voluntary Standards

AN INTERESTING, cleverly illustrated brochure has been issued by the American Standards Association entitled "Voluntary Standards." This is designed to give information about the work of the A.S.A., and in general to give a better appreciation of the importance of standards and what they mean to various groups. Copies can be obtained from the A.S.A. Office, 70 East 45th St., New York 17, N. Y.

## A.S.A. Year Book

THE American Standards Association has published its 1945-1946 Year Book. This is the first Year Book published by the Association since 1938. It, therefore, contains much new material of value to engineers, executives, and technical students.

The book gives information about officers and members of the Board of Directors, of the Standards Council, and other policy-forming committees of the American Standards Association. It also carries such basic documents as the Constitution and By-Laws of the A.S.A.; and much information about the setup of the organization and how standards are developed.

The center section of the book is devoted to a listing of approved American Standards and projects under development together with the scopes of these projects and names of officers and members of active technical committees.

Those interested may obtain copies of the Year Book free of charge by writing to the American Standards Association at 70 East 45th Street, New York 17, N. Y.

## The Metallurgy of Steel Castings

THIS new book by Dr. Charles W. Briggs, Technical and Research Director, Steel Founders' Society of America, in the words of the author "has not been prepared solely for the technical man in the steel casting industry." One of the country's outstanding authorities in this field, one who has contributed a great deal to the important place occupied by the A.S.T.M. standards and technical work, Dr. Briggs has devoted intensive effort and much time in making the publication of interest not only to the technical man in the castings industry but to others by providing a wealth of information and data that could be understood readily by operating men and other workers in the industry—by designing engineers and metallurgists of other industries, and by those who must purchase castings.

In his preview, Dr. Briggs points out that "the point of view taken in this book is one of technical control of all manufacturing operations for the production of steel castings. The quality control of a product cannot be properly formulated without a thorough understanding of the technical problems encountered. It is the sincere hope of the author that this book will provide the foundation for that understanding."

The book covers some 642 pages. There are 334 well-selected figures giving pertinent information in readily understandable form, and there are some 85 tables of data. Dr. Briggs has chosen wisely to in-



clude at the end of most of the chapters an extensive bibliography; the chapter on "Inspection and Properties" notes 15 references, while the one on "Welding of Steel Castings" has 48. A list of chapter headings and approximate number of pages in each will give some idea of the coverage of a large number of topics.

|  | pages |
|--|-------|
| I Basic Practice for the Production of Steel for Steel Castings..... | 61    |
| II Acid Practice for the Production of Steel for Steel Castings..... | 66    |
| III Gases, Deoxidation, Porosity, and Inclusions.....                | 33    |
| IV Tapping and Pouring.....  | 5     |
| V Liquid Cast Steel—Liquid Contraction and Fluidity.....             | 18    |
| VI The Solidification of Steel Castings.....                         | 66    |
| VII Gates and Risers.....  | 52    |
| VIII Contraction in the Solid State.....                             | 16    |
| IX Hot-Tear Formation.....   | 22    |
| X Steel Molding Sands and Cores.....                                 | 61    |
| XI Effect of Molten Steel on Sands, Cores, and Washes.....           | 45    |
| XII Casting Defects.....   | 5     |
| XIII Cleaning, Chipping, and Grinding of Steel Castings.....         | 44    |
| XIV Heat-Treatment and Metallography.....                            | 56    |
| XV Welding of Steel Castings.....                                    | 10    |
| XVI Inspection and Properties.....                                   | 27    |

Other leading technical men cooperated with Dr. Briggs in preparing this book thus providing a thoroughly comprehensive and broad point of view.

This publication is one in the Metallurgy and Metallurgical Engineering Series issued by the McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y., and can be obtained from the publisher at \$6.50 per copy.

## Bulletin on Flow Characteristics of Greases

THE National Lubricating Grease Institute has just issued a new Technical Bulletin entitled "Determination of the Flow Characteristics of Lubricating Greases." This Technical Bulletin covers in detail the development of a pressure-viscosimeter suited for determining the apparent viscosities of lubricating greases over a considerable range of rates of shear.

The viscosimeter instrument and its method of operation are described and additional chapters in the Bulletin deal with the significance and application of grease viscosity data.

Copies of the N.L.G.I. Bulletin may be procured from C. E. Bolte, Secretary, National Lubricating Grease Institute, 1116 Land Bank Bldg., Kansas City, Mo., at \$1.00 each.

## Journal of Research

BEGINNING with the July, 1946, issue the *Journal of Research* of the National Bureau of Standards is issued in new typographic style and size. The older, smaller page size, which is now so familiar to many A.S.T.M. members, is replaced by an increased size which is more in line with that used by many technical magazines and journals, and is the same as the Bureau's *Technical News Bulletin*. The technical papers are being set in a double-column format with larger type.

This issue begins the 37th semi-annual volume of this periodical which is aimed to cover fundamental researches carried out in the laboratories of the Bureau, with each issue covering new developments in science and technology. Subscriptions can be sent to the Superintendent of Documents, U. S. Government Printing Office, the annual charge being \$3.50 for the United States, Canada, Cuba, Mexico, Newfoundland, and Panama; other countries, \$4.50.

## Circulars on Proving Rings, Fire Resistance, and Sound Ratings, and Flame proofing of Textiles

RECENT circulars issued by the National Bureau of Standards, Washington, D. C., cover several subjects which are of interest to a large number of A.S.T.M. members and technical people. These relate to Proving Rings for Calibrating Testing Machines; Fire Resistance and Sound-Insulation Ratings for Walls, Partitions and Floors; and Flameproofing of Textiles. The announcement on proving rings, Circular C454, points out:

The proving ring is a portable device for calibrating testing machines. It can be calibrated and transported conveniently to the testing machine for measuring the forces applied by the machine. The proving ring is essentially an elastic ring of heat-treated alloy steel to which forces may be applied along a diameter. The change in diameter caused by the force is measured by a screw micrometer. Proving rings with capacities from a few hundred pounds to 300,000 pounds, which are being produced commercially, now provide satisfactory means for calibrating testing machines up to about 2,000,000 pounds capacity. . . .

The circular describes the proving ring, its calibration, and use, and gives a specification for proving rings. A discussion of the errors which may arise from unusual conditions of use is also included. The results given indicate that the errors of the proving ring are small compared to the generally recognized tolerance of  $\pm 1$  per cent for testing machines.

| Number  | Kind              | Cu, % | Mg, % | Si, % | Fe, % | Mn, % | Ni, % | Cr, % | Ti, % | Zn, % |
|---------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 601.... | Wrought alloy 14S | 4.38  | 0.39  | 0.88  | 0.52  | 0.81  | ...   | 0.020 | 0.015 | ...   |
| 602.... | Wrought alloy 24S | 4.44  | 1.49  | 0.130 | 0.28  | 0.63  | ...   | 0.007 | 0.012 | ...   |
| 603.... | Wrought alloy 61S | 0.29  | 1.01  | 0.52  | 0.21  | ...   | ...   | 0.24  | 0.037 | ...   |
| 604.... | Casting alloy 142 | 3.98  | 1.56  | 0.27  | 0.45  | ...   | 2.00  | ...   | 0.100 | 0.029 |

The circular on fire-resistance and sound-insulation ratings presented for walls, partitions and floors (Circular TRBM44) gives:

Fire-resistance and sound-insulation ratings of more than 500 floor, partition, and wall constructions, representing masonry, wood, and metal types... in 22 tables and sound-insulation ratings in 13 tables, under the general headings masonry walls; wood-stud, steel-stud, and solid plaster partitions; and wood-or-steel-joist, concrete, and steel-plate floors. The fire-resistance ratings are based in general on tests made in the Bureau's Fire Resistance Section, according to the Standard Specifications for Fire Tests of Building Construction and Materials (A.S.T.M., C 19-41; A.S.A. No. A2.1-1942); some, however, were made by Underwriters Laboratories and at the Ohio State University. The sound-insulation tests were made in the Bureau's Sound Section by methods described in Building Materials and Structures Report BMS17, and supplement, "Sound Insulation of Wall and Floor Construction."

The circular on Flameproofing of Textiles includes a review of the principles of flameproofing, a brief history of researches, and formulas for various processes. An outline of testing methods and requirements for the treated material are also given.

For the treated or intrinsically slow-burning materials a flame test with the fabric in vertical position is outlined. As vertical flame tests are not suitable for comparing the rates of burning of untreated fabrics, a method for determining the rate of burning in horizontal position is also described. Wool, weighted silk, and nylon show little flame spread in this test. Cotton and rayon textiles in the usual weaves will burn at rates from 3 to 25 in. per min. and thin nets and pyroxylin-coated fabrics at greater rates.

A few types of fine-napped rayon and cotton goods will burn at rates in the range 100 to 400 in. per min. Garments made of textiles with such rapid rates of burning represent a serious potential hazard, as evidenced by deaths and burns resulting from their use. However, many textiles with nap of shorter or coarser fibers present no unusual hazard in this respect. The method outlined in the circular is designed to differentiate between these types.

## Spectrographic Standard Samples of Aluminum Alloys

FOUR spectrographic standard samples of aluminum alloys are now available from the National Bureau of Standards. The standards, prepared with the cooperation of the Aluminum Company of America, are in the form of disks 2½ in. in diameter and ¼ in. thick. The identifications and compositions of the alloys follows.

The standards may be obtained from the Bureau at a price of \$8.00 per specimen.

## Calendar of Society Meetings

1946

- AMERICAN INSTITUTE OF STEEL CONSTRUCTION—Annual Convention, October 28, Coronado, Calif.
- SEVENTH ANNUAL WATER CONFERENCE—October 28, 29, 30, Hotel William Penn, Pittsburgh, Pa. (E.S.W.Pa.)
- SOCIETY OF AUTOMOTIVE ENGINEERS—National Fuels and Lubricants Meeting, November 7-8, Mayo Hotel, Tulsa, Okla.
- AMERICAN PETROLEUM INSTITUTE—Twenty-sixth Annual Meeting, November 11-14, Stevens Hotel, Chicago, Ill.
- AMERICAN WELDING SOCIETY—Annual Meeting, November 17-22, Atlantic City, N. J.
- NATIONAL METAL CONGRESS EXPOSITION—November 18-22, Atlantic City, N. J.
- SOCIETY OF AUTOMOTIVE ENGINEERS—Air Transport Meeting, December 2-4, Chicago, Ill.
- AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting, December 2-6.
- NATIONAL POWER SHOW—December 2-7, New York, N. Y.
- ELECTRONIC MICROSCOPE SOCIETY OF AMERICA AND AMERICAN SOCIETY FOR X-RAY AND ELECTRON DIFFRACTION—1946 Winter Meeting, December 5-7, Mellon Institute and University of Pittsburgh, Pittsburgh, Pa.
- HIGHWAY RESEARCH BOARD—Annual Meeting, December 5-8, National Academy of Sciences and National Research Council Building, Washington, D. C.
- AMERICAN SOCIETY OF REFRIGERATING ENGINEERS—Annual Meeting, December 16-18, New York, N. Y.
- AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS—Annual Meeting, December 17-20, Biltmore Hotel, Los Angeles, Calif.
- AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—Annual Meeting, December 26-31, Boston, Mass.

1947

- American Society for Testing Materials—Spring Meeting and Committee Week, February 24-28—Hotel Benjamin Franklin, Philadelphia, Pa.
- AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Seventy-fifth Anniversary Celebration, with World Conference on Mineral Resources, and Annual (February) Meeting, March 17-22, Waldorf-Astoria Hotel, New York, N. Y.
- American Society for Testing Materials—Annual Meeting, June 16-20, Chalfonte-Haddon Hall, Atlantic City, N. J.

## Catalogs and Literature Received

SUPERIOR ELECTRIC Co., Bristol, Conn. Bulletin No. 150 fully describes all the standard products manufactured by Superior. Under one cover are charts, circuit diagrams, and other data pertaining to Powerstat Variable Transformers, Seco Automatic Voltage Regulators, and Volt-box a-c power supplies. Detailed descriptions as well as illustrations are given for the various pieces of equipment. 12 pages.

SCIENTIFIC GLASS APPARATUS Co., INC., 49 Ackerman St., Bloomfield, N. J. An eight-page folder entitled "The Improved Heating Jacket" describes Gyco Heating Jackets and the Gyco Pyro-Tran. Numerous details are given as well as illustrations of tubular heating jackets, jacket supports, transformer, and pyrometer in one instrument, and various new glass specialties.

GEORGE SCHERR Co., INC., 200 Lafa-

yette St., New York 12, N. Y. A new eight-page folder devoted to Scherr Micrometers, formerly manufactured under the name of Reed. The folder discusses Scherr's micrometer manufacturing methods and announces further the fact that all Scherr micrometers in the one, two, and three-inch sizes are now provided with a 0.0001 in. vernier without extra charge. Illustrated also are various inspection procedures such as checking parallelism and flatness of spindle end and anvil.

FERRY MACHINE Co., Kent, Ohio. A 34-page publication, 8½ by 11, describing "Specifications and Data—B. F. Goodrich-Cord Tension Vibrator." This is an instrument for the measurement of fatigue in mechanical fabrics. Chapter headings cover the following: General Description of Test, General Description of Machine, Procedure in Making Test, Preparation of Machine for Starting Test, and three technical papers reprinted from *Textile World*, *Journal of Applied Physics*, and *ASTM BULLETIN*, as follows: "Tension Vibrator Compares Tire-Cord Values," "Fatigue of Fabrics," and "Statistical Comparison of Rayon Tire-Cord Fatigue Testing Machines." Several full-page illustrations are included, as well as a number of tables, charts, and diagrams.

## Society Appointments

ANNOUNCEMENT is made of the following appointments to Society Administrative and other committees:

H. F. DODGE, Bell Telephone Laboratories, Inc., and A. E. R. WESTMAN, Ontario Research Foundation, as the Society's representatives on the Joint Committee on Statistical Applications in Engineering and Manufacturing, succeeding A. G. ASHCROFT and W. H. FULWEILER.

LEO SCHAPIRO, Douglas Aircraft Co., on the Joint Committee on Effect of Temperature on the Properties of Metals.

G. N. THOMPSON, National Bureau of Standards, on the Administrative Committee on Ultimate Consumer Goods.

H. K. NASON, Monsanto Chemical Co., on the Administrative Committee on Papers and Publications, succeeding L. M. CURRIE.

K. D. WILLIAMS, U. S. Navy, and E. L. HOLLADY, U. S. Army, on the Administrative Committee on Simulated Service Testing succeeding W. S. NEWTON and S. B. RITCHIE, respectively.

MYRON PARK DAVIS, Otis Elevator Co., as the Society's representative on the A.S.A. Safety Code Correlating Committee.

R. L. SANFORD, National Bureau of Standards, as the Society's representative on Sectional Committee C 61 on Electric and Magnetic Magnitudes and Units, succeeding W. J. SHACKELTON.

G. C. MACDONALD, Montgomery Ward, with JULES LABARTHE, Mellon Institute, as alternate, as the Society's representative on the Sectional Committee Z 36 on Definitions of Terms Used to Describe Commodities Sold at Retail.

J. R. BECKER, as the Society's representative on the Sectional Committee C-8 on Specifications for Insulated Wires and Cables (Other than Telephone and Telegraph), succeeding Dean Harvey, Consulting Engineer.

1947 Edgar Marburg Lecture Committee: J. R. TOWNSEND, Bell Telephone Laboratories, Inc., Chairman; J. W. BORTON, The Lunkenheimer Co.; and W. H. GARDNER, Allied Chemical and Dye Corp. (This committee includes a member from the Board of Directors, the Administrative Committee on Papers and Publications, and the Administrative Committee on Research.)

1947 Dudley Medal Committee: F. M. HOWELL, Aluminum Company of America, Chairman; J. V. EMMONS, The Cleveland Twist Drill Co.; J. J. KANTER, Crane Co.; STANTON WALKER, National Sand and Gravel Assn.; and J. M. WEISS, John M. Weiss and Co.

Templin Award Committee: R. E. PETERSON, Westinghouse Electric Corp., has been appointed a member of the committee this year, the other members being W. E. EVANS, Chairman, and L. W. TELLER, Bureau of Public Roads.

## Schedule of A.S.T.M. Meetings

| DATE                       | COMMITTEE   | PLACE                      |
|----------------------------|---|----------------------------|
| October 16-18              | D-13 on Textile Materials                         | New York City              |
| October 23                 | D-5 on Coal and Coke, Sub. II; Sub. XVII; Sub. XX | Headquarters, Philadelphia |
| October 30, 31, November 1 | B-4 on Electrical Heating                         | Atlantic City              |
| November 6                 | D-1 on Paint, Varnish, etc.—Advisory              | Atlantic City              |
| November 7                 | CLEVELAND DISTRICT                                | Cleveland                  |
| November 13                | DETROIT DISTRICT                                  | Detroit                    |
| November 14                | PHILADELPHIA DISTRICT                             | Philadelphia               |
| November 14                | C-8 on Refractories                               | Columbus                   |
| November 15                | ST. LOUIS DISTRICT                                | St. Louis                  |
| November 18                | E-1 Section on Compression Testing                | Atlantic City              |
| December 2                 | PITTSBURGH DISTRICT                               | Pittsburgh                 |
| December 3                 | C-1 on Cement                                     | Washington, D. C.          |
| December 3                 | C-9 on Concrete and Concrete Aggregates           | Washington, D. C.          |
| December 12                | NEW YORK DISTRICT                                 | New York City              |
| January 7, 1947            | CHICAGO DISTRICT                                  | Chicago                    |
| January 23                 | PHILADELPHIA DISTRICT                             | Philadelphia               |
| February 24-28             | SPRING MEETING AND COMMITTEE WEEK                 | Philadelphia               |
| June 16-20                 | 50TH ANNUAL MEETING                               | Atlantic City              |



## New Members to September 30, 1946

The following 81 members were elected from July 22 to September 30, 1946, making the total membership 6090.

Names are arranged alphabetically—company members first, then individuals.

### Chicago District

CECO STEEL PRODUCTS CORP., H. F. Machamer, Director of Research, 5701 W. Twenty-sixth St., Chicago 50, Ill.  
STERLING TOOL PRODUCTS CO., S. A. Crosby, President, 363 E. Ohio St., Chicago 11, Ill.  
BATES, A. ALLAN, Vice-President for Research and Development, Portland Cement Association, 33 W. Grand Ave., Chicago 10, Ill.  
BUDZ, JOHN R., Physical Tester, Chicago Latrobe Twist Drill Works, 411 W. Ontario St., Chicago 10, Ill.  
PRICE, DAVID S., Manager, Merchandise Research Lab., Spiegel, Inc., 1061 W. Thirty-fifth St., Chicago 9, Ill.  
SAFARIK, EDGAR R., Chief of Inspection, Leich Electric Co., Genoa, Ill. For mail: Box 251, Genoa, Ill.  
ZEST, CHARLES J., Technical Director, Container Testing Laboratories, Inc., 112 W. Kinzie St., Chicago 10, Ill. For mail: 41 Salem Lane, New England Village, Evanston, Ill.

### Cleveland District

ANTHONY, CLIFFORD L., Sales Manager, The Hoover Co., North Canton, Ohio.  
MARTIN, STEWART, Chief Engineer, Standard Steel Spring Co., Newton Falls, Ohio.  
ROMER, JOHN B., Chief Chemist, Babcock & Wilcox Co., Barberton, Ohio. For mail: 4554 Lahm Dr., Box 521, R.D. 4, Akron 1, Ohio.

### Detroit District

TAMM, ROBERT E., Project Engineer, Superdual Corp., Ford and Miller Rds., Dearborn, Mich.  
WILCOX, RALPH, Plant Superintendent, Detroit Division, Gerity-Michigan Die Casting Co., 8651 E. Seven Mile Rd., Detroit 12, Mich.

### New England District

CARR MANUFACTURING CORP., C. F. Hoover, Chief Chemist, Box 383, Bristol, R. I.  
BINDER, WILLIAM V., Chemist, Roston Varnish Co., Everett Station, Boston, Mass.  
BORIN, WALTER E., Chemist and Metallurgist, Underwood Corp., General Research Lab., 56 Arbor St., Hartford, Conn. For mail: 134 George St., Hartford 6, Conn.  
BRADLEY, JOHN J., Jr., Technical Director, Boston Varnish Co., Everett Station, Boston, Mass.  
FLETCHER, RALPH A., Treasurer, H. E. Fletcher Co., Box 71, West Chelmsford, Mass.  
GINSBURGH, ALLEN S., Engineer, United Aircraft Corp., Research Dept., 400 Main St., East Hartford, Conn. For mail: 25 Gillett St., Hartford 5, Conn. [J]†  
SIMON, S. A., Chief Chemist, Chicopee Manufacturing Co., Chicopee Falls, Mass. For mail: 34 Bliss Rd., Longmeadow 6, Mass.

### New York District

ANGLO-IRANIAN OIL CO., LTD., LONDON, ENGLAND, B. R. Jackson, Representative in U.S.A., 610 Fifth Ave., New York 20, N. Y.  
TRIBAUT & WALKER CO., INC., Samuel C. Robison, Technical Director, 5-48 Fortysixth Rd., Long Island City, N. Y.  
UNIVERSAL PIGMENT AND CHEMICAL CORP., Harold E. Weisberg, President, 352 Doremus Ave., Newark 5, N. J.  
BEUSCHER, WILLIAM C., Technical Director, Housing Authority of Jersey City, 514

Newark Ave., Jersey City 6, N. J. For mail: 50 Reservoir Ave., Jersey City 7, N. J.

HIRST, BERNARD, Metallurgist, B-M Heat Treating Co., 220 Clifford St., Newark 5, N. J. For mail: 300 Ocean Parkway, Brooklyn 18, N. Y.

HOTTE, GEORGE H., Textile Technologist, A. M. Tenney Associates, Inc., 10 E. Fortieth St., New York 16, N. Y.

RUTGERS UNIVERSITY, SCHOOL OF CHEMISTRY, William Rieman III, Professor of Analytical Chemistry, New Brunswick, N. J.

WENIGER, SIDNEY, Plant Engineer, Cleaveland Laboratories and Manufacturing Co., Inc., Peapack, N. J. For mail: Califon, N. J.

WINTER, MARTIN H., Partner, Standard Ink and Color Co., 129 Atkins Ave., Brooklyn 8, N. Y. [J]†

### Northern California District

BARTON, J. E., Assistant Physical Testing Engineer, California State Division of Highways, 3435 Serra Way, Sacramento 16, Calif.

DUKE, CHARLES MARTIN, JR., Senior Testing Engineer, Pacific Islands Engineers, Contract NOY 13626, Commander Marianas, Box 33, c/o Fleet Post Office, San Francisco, Calif.

### Philadelphia District

NEW HOLLAND MACHINE CO., C. B. Walls, Jr., Methods Engineer, New Holland, Pa.  
REESE, GEORGE E., Assistant Chief Refinery Chemist, Sun Oil Co., Marcus Hook, Pa.  
SMITH, SYLVESTER LEROY, Architect, 250 N. Fifteenth St., Philadelphia 2, Pa.  
THOMPSON, NORMAN, Section Chief, Sun Oil Co., Marcus Hook, Pa.

### Pittsburgh District

LABOON, JOHN F., Chairman of Board, Allegheny County Sanitary Authority, 502 City-County Bldg., Pittsburgh, Pa.  
MACGREGOR, A. R., President, Alloy Specialties Co., Box 8274, Swissvale, Pittsburgh 18, Pa.

### St. Louis District

ROSE AND CO., D. M., D. M. Rose, Owner, 1155 Blackstone Ave., St. Louis, 12, Mo.

### Southern California District

NATIONAL TECHNICAL LABORATORIES, E. D. Haller, Chemical Engineer, Box 309, South Pasadena, Calif.  
BERGSTROM, CHARLES W., Laboratory Technician, 476 W. Thirty-ninth St., San Pedro, Calif.  
HEISKELL, RAYMOND H., Partner, Industrial Testing and Research Laboratories, 517 S. Alameda Blvd., Compton, Calif.  
HUNTER, ANTHONY, Head, Specifications Dept., Donald R. Warren Co., 500 S. Figueroa St., Los Angeles, Calif. For mail: 1610 N. Normandie St., Los Angeles, Calif.  
REXFORD, ELLIOT P., Geologist, U. S. Engineer Office, Los Angeles District, 751 Figueroa St., Los Angeles, Calif. For mail: 1669 Elizabeth St., Pasadena 7, Calif.

### Western New York and Ontario District

EATON CO., LTD., THE T., Research Bureau, E. J. Tyrrell, Chief Chemist, 190 Yonge St., Toronto, Ont., Canada.  
WOBURN CHEMICALS, LTD., T. H. Glynn Michael, Chief Chemist, Beechwood Dr., Don Valley, Toronto 6, Ont., Canada.

### U. S. and Possessions

ANSCO DIVISION, GENERAL ANILINE AND FILM CORP., Victor Hicks, Binghamton, N. Y.  
CORWIN AND CO., INC., William J. Wenzel, Chief Engineer, 413 Medical Arts Bldg., Great Falls, Mont.  
DEERING, MILLIKEN RESEARCH TRUST, J. N. Dow, Vice-President, Box 700, Clemson, S. C.  
EAGLE-PICHER SALES CO., THE, Insulation

Division, Harry E. Lewis, Manager, Insulation Engineering Dept., American Bldg., Cincinnati 1, Ohio.

HOBART MANUFACTURING CO., F. D. Houser, Chief Engineer, Pennsylvania Ave., Troy, Ohio.

HYDROTEX INDUSTRIES, Box 2400, Dallas 1, Tex.

BENHAM, WEBSTER L., Owner and Chief Engineer, Benham Engineering Co., 550 American National Bldg., Oklahoma City 2, Okla.

BRECKENRIDGE, FRANK, Vice-President, Automatic Washer Co., Newton, Iowa.

CURRY, REMBERT L., Chemist, Concrete Research Division, U. S. Waterways Experiment Station, Clinton, Miss.

DEWEY, HARRY M., Civil Engineer, Civil Engineering Service, Inc., 2907 S.E. Hawthorne Blvd., Portland 15, Ore. For mail: 11356 N.E. Fremont Court, Portland 16, Ore.

EVANS, WILLIAM S., Architect and Engineer, 617 Ardis Bldg., Shreveport 23, La.

GREACEN, THOMAS E., II, Architect, 1010 Winbern St., Houston 4, Tex.

HARLEY, JOHN H., Instructor, Walker Laboratory, Rensselaer Polytechnic Institute, Troy, N. Y.

HOLTZ, WESLEY G., Head, Earth Materials Lab., U. S. Bureau of Reclamation, Denver 2, Colo.

HOOGE, CLIFFORD C., 2531 Kemper Lane, No. 203, Cincinnati 6, Ohio.

HOPPE, M. R., Vice President, Parr Instrument Co., 211 Fifty-third St., Moline, Ill.

JACKSON, LAWRENCE B., Director of Engineering, Diesel Division, American Locomotive Co., Schenectady 5, N. Y.

KELLY, THOMAS M., Materials Engineer, National Bureau of Standards, Washington 25, D. C.

KOHN, LEON, Graduate Assistant, Oklahoma Agricultural and Mechanical College, Stillwater, Okla. [J]†

NEWMAN, SANFORD BERNHART, Associate Microbiologist, National Bureau of Standards, Connecticut Ave. and Van Ness St., Washington, D. C. For mail: 7105 New Hampshire Ave., Takoma Park, Md.

ROWAN, WILLIAM H., Associate Professor, Vanderbilt University, School of Engineering, Box 70, Nashville, Tenn.

SNIDER, SIDNEY R., Chemist, U. S. Department of Agriculture, Washington, D. C. For mail: 3001 Twentieth St., N.W., Washington 18, D. C.

STARR, CHARLES E., JR., Assistant Director, Esso Laboratories, Standard Oil Co. of New Jersey, Louisiana Division, Box 551, Baton Rouge 1, La.

STIEHLER, ROBERT D., Rubber Technologist, National Bureau of Standards, Rubber Section, Washington 25, D. C.

TYNER, HOWARD D., Director, Rocky Mountain Institute for Industrial Research, Palmer Hall, Colorado College, Colorado Springs, Colo.

UNIVERSITY OF UTAH LIBRARY, Salt Lake City 1, Utah.

VAN ECHO, ANDREW, Chief Inspector, Joslyn Manufacturing and Supply Co., Ft. Wayne, Ind.

WEST, JOHN W., Professional Engineer and Land Surveyor, 500 E. Broadway, Hobbs, N. Mex. [J]†

### Other than U. S. Possessions

GIA, SOROCABANA DE MATERIAL FERROVIARIO, Mariano, J. M. Ferraz, Managing Director, Rua Benjamin Constant, 61 Sao Paulo, Brazil.

DISTILLERS CORP., LTD., Adalbert Herman, Director of Research, 1430 Peel St., Montreal 2, P.Q., Canada.

SOCIEDADE TECNICA DE FUNDICÖES GERAES, Otto Barcellos, President, Rua Bao Vista, Sao Paulo, Brazil.

CRICHTON, D. C., Chief Chemist, The Associated Portland Cement Manufacturers, Ltd., Research Dept., Rosherville Court, Burch Rd., Gravesend, Kent, England.

GRALÉN, NILS, Director, Svenska Textilforskningsinstitutet, Nya Chalmers, Gothenburg, Sweden.

INDIA DEPARTMENT OF INDUSTRIES AND CIVIL SUPPLIES, Secretary, Government of India, New Delhi, India.

MARROQUIN, CARLOS F., Mechanical and Electrical Engineer, Box 2565, Mexico City, Mexico.

PARRY, WILLIAM F., Superintendent, Bruck Silk Mills, Ltd., Cowansville, Que., Canada. For mail: 204 William St., Cowansville, Que., Canada.

VALLE-RODAS, RAUL, Materials Engineer, Highway Dept., Departamento de Carreteras, Managua, Nicaragua.  
† [J] Denotes Junior Member.

## Personals . . .

*...News items concerning the activities of our members will be welcomed for inclusion in this column.*

JAMES T. KEMP has returned from London, England, where he was serving as Chief Mission Officer, Conservation Mission for Economic Affairs, U. S. Embassy. He is connected with the American Brass Co. as Metallurgical Engineer.

HERBERT S. KARCH has returned from overseas with the Armed Forces and has joined The C. P. Hall Co., Akron, Ohio, which company he will represent in the A.S.T.M.

J. R. THOMAS, formerly Superintendent, Pennsylvania-Dixie Cement Corp., Kingsport, Tenn., is now Assistant Superintendent of Shops and Maintenance Division, Tennessee Eastman Corp., Kingsport, Tenn.

H. C. GRAVES, JR., formerly Engineering Manager at I-T-E Circuit Breaker Co., Philadelphia, Pa., is now Chief Engineer with Gibson Electric Co., Pittsburgh, Pa.

D. G. MILLER is now Materials Engineer connected with the Public Roads Administration, Federal Works Agency, University of Minnesota, St. Paul, Minn. He was formerly Senior Drainage Engineer with the Soil Conservation Service of the U. S. Department of Agriculture, University of Minnesota.

RALSTON RUSSELL, JR., who was connected with Westinghouse Electric Corp., East Pittsburgh, Pa., as Director of Ceramic Research, is now Professor of Ceramic Engineering at the Ohio State University, Columbus, Ohio.

R. S. BURPO, JR., is now Assistant Professor of Physics at the Massachusetts State College, Amherst, Mass. He was formerly Associate Editor of *Materials and Methods*, New York, N. Y.

W. L. SAWYER has returned to the University of Florida, Gainesville, as Professor of Civil Engineering. He has been Resident Officer in charge of Construction with the U. S. Navy in Homestead, Fla.

L. R. FORBRICH, who was formerly Chemical Research Engineer, The Bessemer Limestone and Cement Co., Youngstown, Ohio, is now Chief Chemist, The Green Bag Cement Co. of Pennsylvania, Pittsburgh, Pa.

H. D. BAYLOR of the Louisville Cement Corp. is now President of the company. He was formerly Vice-President.

H. D. CLAYTON is retiring from Cluett, Peabody and Co., Inc., New York, N. Y., in the very near future.

M. U. COHEN is at present Associate Research Director, The General Research Laboratories, Newark, N. J. He was formerly Associate Laboratory Di-

rector of the Gussack Machined Products Co., Long Island City, N. Y.

LIEUTENANT COLONEL W. H. BASSETT, JR., is now at Ordnance Department, Missouri Ordnance Works, Louisiana, Mo. He was formerly stationed at the Army Industrial College, Pentagon Building, Washington, D. C.

W. K. SIMPSON who was Supervisor of Gasoline Testing Laboratory, Universal Oil Products Co., Riverside, Ill., is now Fuel and Lubricant Engineer, at the Electro-Motive Division, General Motors Corp., La Grange, Ill.

C. D. HOCKER is now Associate Professor of Chemistry at Union College, Schenectady, N. Y. He was formerly Plant Products Engineer, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BURT WETHERBEE who was Midwest Technical Representative, General Latex and Chemical Corp., Snyder, N. Y., is now Owner of the Wetherbee Chemical Co. in Snyder.

GEORGE E. HULSE retired from active duty on September 1 with The Safety Car Heating and Lighting Co., Inc., New Haven, Conn.

RANDALL C. SMITH, who was formerly Unit Head, Structures Department, Curtiss-Wright Corp., Columbus, Ohio, is now Chief of Structures of East Coast Aeronautics, Inc., New York, N. Y.

J. R. CURREY is Chemical Consultant at Virgil J. Green and Associates, Dayton, Ohio. He was Supervisor, Fuel Test Laboratory, U. S. Army Air Forces, Wright Field, Dayton, Ohio.

H. P. PEARSON is now Manager, Soilpak Division, Service Engineering Co., Summit, N. J. He was formerly Technical Director at The Kotal Co., New York, N. Y.

C. H. BONNEY who was connected with New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico, as Assistant Professor of Civil Engineering, is now Head of the Engineering Department at Arkansas State College, Jonesboro, Ark.

K. B. ANDRUS, formerly Technical Service Representative of the Corning Glass Works, Corning, N. Y., has accepted a position with Coleman Instruments, Inc., in Maywood, Ill.

F. H. KELLOGG is connected with the University of Mississippi, Oxford, Miss., as Professor of Civil Engineering. He was formerly a Civil Engineer located in Omaha, Nebr.

THEODORE A. WERKENTHIN, Principal Materials Engineer, Civilian-in-Charge of the Rubber and Plastics Section of the Bureau of Ships, was recently presented with the Meritorious Civilian Award for outstanding service in connection with all research and technological problems on natural rubber, synthetic rubber and plastic elastomers during

World War II, the presentation having been made by Vice Admiral E. L. Cochran, Chief of the Bureau of Ships.

WILLIAM A. MUDGE, Assistant Director, New York Technical Section, Development and Research Division, International Nickel Co., Inc., has been elected chairman of the New York Chapter of American Society for Metals for the year 1946-1947.

R. J. ALLEN, Metallurgical Engineer, Worthington Pump and Machinery Corp., East Harrison, N. J., has been appointed head of the 1946-1947 program and papers committee, Gray Iron Division, American Foundrymen's Association, Chicago.

WILLIAM T. GRIFFITHS, Chairman and Managing Director, Mond Nickel Co., Ltd., and a Vice-President of its parent company, International Nickel Co. of Canada, Ltd., Copper Cliffs, Ont., has been knighted by King George. Knighthood was bestowed upon him in recognition of his public services, particularly during the war, when he was a metallurgical consultant to the British Services and Production Ministries, and a member of several metallurgical, research, and materials committees.

RALPH L. WILCOX is now Plant Superintendent of the Detroit Division of the Gerity-Michigan Die Casting Co. For many years Mr. Wilcox has been associated with the New Jersey Zinc Co., and, during the war, he served for several years on the staff of the Conservation Division of the War Production Board.

The following two men who are active in A.S.T.M. work have been nominated for President and Vice-President, respectively, of the American Society for Metals: A. L. BOEGEHOLD, Head of the Metallurgy Department, Research Laboratories Division, General Motors Corp., and FRANCIS B. FOLEY, Superintendent of Research, The Midvale Co.

GEORGE H. HARNDEN, whose former address was Works Laboratory General Electric Co., Schenectady, N. Y., has moved to the Standards Division, Executive Department, General Electric Co., Schenectady, N. Y.

F. R. HENSEL has been elected Vice-President in Charge of Engineering of P. R. Mallory & Co., Inc., Indianapolis, Ind. He has been Chief Metallurgical Engineer for the Mallory Co. since 1934.

ROYAL M. HOCHNER has returned to inactive duty and civilian status after serving in the U.S.N.R. and is again employed by The Firestone Tire and Rubber Co. in the Development Department as a Mechanical Engineer writing tire specifications.

GEORGE HEWITT KNODE has returned from foreign duty in Germany as Major with the U. S. War Department, Ordnance Department and is again with The Pennsylvania Railroad Co. in Altoona, Pa.



JAMES S. MACGREGOR has retired from active business. He was Director, Miscellaneous Minerals Division, War Production Board, Washington, D. C.

RAY L. HANKINSON has retired as a Commander, U. S. Coast Guard and Assistant Chief, Civil Engineering Section, Washington, D. C.

FRANCIS S. BRANIN was formerly Vice-President and General Manager of the Middlesex Mfg. Co., Inc., Middlesex, N. J., and is now President of the Asphaltic Specialties Co., Inc., Peapack, N. J.

A. R. MAUPIN is now Metallurgical Engineer of the Civilian Production Administration, Washington, D. C. He was formerly Consultant of the Tin-Lead Zinc Division, War Production Board, Washington, D. C.

F. B. HORNIBROOK, formerly Materials Engineer, National Bureau of Standards, Washington 25, D. C., is now connected with the Master Builders Research Laboratories, Cleveland, Ohio, as Assistant Director of Research.

LESTER A. LANNING, recently appointed Manager of the Sandusky Plant, New Departure Division, General Motors

Corp., now under construction, has taken up residence in Sandusky, Ohio, to direct completion of the plant, and to take charge of operations when they start. Mr. Lanning has been with the division 27 years, and had been assistant plant manager of Bristol, Conn. since 1939.

J. G. FINK, formerly on the staff of the National Lime Association, and serving in a research capacity at the National Bureau of Standards, has been appointed Executive Secretary of The Oxychloride Cement Association, Inc., which is located in Washington. Dr. Fink had been serving as the Secretary of Committee C-7 on Lime and has relinquished this service in his new capacity.

S. B. RITCHIE, Office of the Chief of Ordnance, is now on Terminal Leave preparatory to retirement from active service in the Army. For a great many years he has taken a most active part in Ordnance Department work and has been most active in many of the technical advances which have been made. He has cooperated closely in many phases of A.S.T.M. work.

F. W. SMITHER, Chemist at the Na-

tional Bureau of Standards for a great many years, has retired as of August 31. He was very active in A.S.T.M. work, having been Vice-Chairman of Committee on C-12 on Mortars for Unit Masonry.

F. G. STEINEBACH, Editor of *The Foundry*, and Vice-President, Penton Publishing Co., Cleveland, Ohio, will deliver the chief address at the general session to be held during the Regional Foundry Congress sponsored by the Metropolitan, Chesapeake, and Philadelphia Chapters of the American Foundrymen's Association in Philadelphia on November 1 and 2 at Town Hall. His topic will be "Recent Development in the Foundry Industry" and is scheduled for 10 a.m. Friday, November 1. Various group meetings and technical papers are scheduled for this conference covering gray and malleable iron, steel, and brass, bronze, and light metals. The program was published in the October *Foundry*, page 154.

C. E. HOYT retired as Treasurer of the American Foundrymen's Association on August 1 terminating a long period of service to the A.F.A. and the foundry industry.

ANTHONY D. WAGNER, formerly Materials Engineer, Westinghouse Electric Corp., Center Line, Mich., is now Laboratory Manager, Hudson Motor Car Co., Ferndale, Mich.

C. M. STERNE, who has been serving as Lieutenant Commander, U.S.N.R., is now back with Metropolitan Refining Co., Inc., as Chief Engineer, in Long Island City, N. Y.

G. C. CURRY, formerly Manager, War Products Division, The Hoover Co., North Canton, Ohio, is now Manager, Commercial Die Casting Division, Precision Casting Co., Kalamazoo, Mich.

FRANS V. E. VAURIE is now Research Assistant, The Institute of Paper Chemistry, Appleton, Wis. He was Director of Chemical Laboratory, Valley Research Corp., Montague, Mich.

## NECROLOGY

(Dates of death are given where available)

GILBERT E. SEIL, Technical Consultant, Day & Zimmermann, Inc., Philadelphia, Pa. (September 11, 1946). Member since 1935.

JOHN RAMSAY, Department of Mechanics and Mechanical Engineer (Retired), The Royal Technical College, Glasgow, Scotland (August 6, 1946). Member since 1924. Mr. Ramsay took a real interest in the work of the Society and about once a year wrote a rather extensive and cordial letter commenting on our work.

JAMES A. SMAIL, Metallurgical Engineer, Republic Steel Corp., Youngstown, Ohio (August 5, 1946). Mr. Smail was a member of Committee A-1 on Steel where he represented his company on Subcommittees II and IX covering Structural Steel for Bridges, Buildings, and Rolling Stock, and Steel Tubing and Pipe, respectively. He was also a member of Committee A-5 on Corrosion of Iron and Steel where he served on Subcommittees VI on Specifications for Metallic-Coated Products and VII on Methods of Testing. He also represented his company on the Joint Committee on Filler Metal. Mr. Smail took an active interest in committees of which he was a member and his many friends and associates in these groups

will miss him. Mrs. Smail and two sons survive.

KENNETH RICE, Director of Physical Testing, Sidney Blumenthal and Co., Inc., Shelton, Conn. (June 27, 1946). Mr. Rice was a member of Committee D-13 on Textile Materials and a number of its subcommittees including B-1 on Methods and Machines, Section II on Machines, and B-5 on Sampling, Presentation and Interpretation of Data.

GUY W. JORDAN, Chief Chemist, Southern States Portland Cement Co., Rockmart, Ga. (September 5, 1946). Mr. Jordan was accidentally killed at the plant. He was a native of Pennsylvania and a resident of California during early life. He first worked in the laboratory of the California Portland Cement Co. and after serving in World War I, he went to the Rockmart position. Mr. Jordan has been an active member of the Society since 1939, and his particular interest in Committee C-1 was with the Sponsoring Committee on Blended Cements. He was an active civic, religious, and community leader. He leaves his wife, the former Miss Essie Hudgins of Gainesville, two daughters, and numerous friends from coast to coast.



Guy W. Jordan

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